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ART. XXXV.—*On the use of Carbon bisulphide in prisms; being an account of Experiments made by the late* DR. HENRY DRAPER *of New York.**

THE photographs which were taken in the research on the presence of oxygen in the sun, in the earlier as well as in the later series of experiments,† were obtained by the use of two hollow prisms filled with carbon bisulphide. These prisms were loaned for this purpose by Mr. Rutherfurd, having been made by him for producing his celebrated solar prismatic spectrum.‡ The photographic work for the oxygen research was done in New York in a back room of the third story of Dr. Draper's residence. The temperature of this room proved to be remarkably uniform, the quality of the photographs and especially the sharpness of definition, being all that could be desired. When however the preliminary experiments required for the continuation and extension of this research were undertaken in the new physical laboratory (which Dr. Draper had

* The results which were obtained by Dr. Draper in his investigations on the cause of the difficulties encountered in the use of carbon bisulphide in prisms seemed so valuable and so likely to be of service to others engaged in photographing the prismatic spectrum, that at the suggestion of several of his scientific friends it was decided to publish them. At the request of Mrs. Draper, therefore, and with her kind assistance, I have collected from Dr. Draper's copious notes the facts in relation to his experiments which are detailed in the following pages; and have also made some supplementary measurements to test the efficiency of the apparatus.—GEORGE F. BARKER.

† This Journal, III, xiv, 89, Aug. 1877; xviii. 262, Oct. 1879.

‡ This Journal, II, xxxv, 407, May, 1863; xxxix, 129, March, 1865.

built above his stable in the rear of his house and which was completed in 1880) it was found practically impossible to use carbon bisulphide prisms in this room owing to the rapid variations of the temperature there. No definition whatever could be obtained with the same prisms which had performed so well in the main house. In consequence, the use of these prisms had to be abandoned and a series of experiments was made to obtain the spectrum by other means. First a Rutherfurd silvered glass grating of 8,640 lines to the inch was employed and subsequently a train of six flint glass prisms made by Steinheil and loaned by Mr. Rutherfurd. With reference to these experiments, Dr. Draper says: "The exposures required when using the silvered grating were so long that experimentation was very teious; but when in addition, the definition did not equal that of the two bisulphide prisms formerly used, a change became necessary. If we could overcome the effect of temperature on bisulphide it would doubtless serve our purpose best, because it is more transparent, less colored and loses less light by reflection than glass prisms since there are only two prisms needed to do the work of four flints. But the instability of a bisulphide train is so marked in the new laboratory on account of the fluctuations of temperature, that we have not been able to depend upon it. Possibly if the prisms were enclosed in cotton batting or immersed in water these difficulties might be overcome."

With the flint prisms, the definition of the sun spectrum was excellent, but it was found impossible to get the line H on the photographic plate, through the train. The silvered glass grating permitted the spectrum from F to a long distance above H to be obtained at one exposure on an eight-inch plate; but the definition given by it on the sun spectrum was inferior to that obtained with the prisms. The definition of the flint train however, good as it was, only equaled and did not surpass that of the bisulphide prisms used in the oxygen research; "the rippled line below G is as well defined" Dr. Draper says, "as I have ever seen it with the two bisulphide prisms." On the spectrum of the carbon arc, the dispersion given by the train between G and H was double that given by the silvered grating in the spectrum of the first order; while that given by "the two bisulphide prisms between G and H is slightly greater than that of the six flint prisms." Moreover, while the definition on the lines of the sun spectrum was best with the flint prisms, that on the spark spectrum lines was best with the grating. These experiments extended through nearly two years, from March, 1880, until early in the winter of 1881–2.

Among the earliest experiments which were undertaken in the new laboratory was a series made to test the performance

of a bisulphide prism of Thollon's construction* made by Hilger of London, and obtained from him by Dr. Draper when in Europe early in 1879. This prism consists of a glass bottle having two plane sides making an angle of 90° with one another, upon which are cemented two prisms of flint glass four by two inches on the face, having each a refracting angle of 18°. The refracting edges of these glass prisms are opposed to that of the bisulphide prism. Hence the refracting angle of the compound prism is 54°. The same difficulties were experienced with this prism as with the Rutherfurd bisulphide prisms. Owing to the temperature-variations, the spectrum lines were "wooly" and no definition was possible. Dr. Draper says: "The bisulphide prism touched with the finger or breathed on loses all definition at once." It was found however, that the dispersive power of the Thollon prism was equal to that of about four of the Steinheil flint prisms; and this fact, together with the unsatisfactory character of the results obtained with the train of prisms as well as with the grating, led Dr. Draper to undertake an investigation into the causes of this unsteadiness of the bisulphide, with a view to remedying it if practicable.

The same difficulty has been encountered by all experimenters who have endeavored to use bisulphide prisms. Mr. Rutherfurd himself found it to be very serious and M. Thollon says such prisms must be protected carefully from temperature-variations. It was while using these prisms that Mr. Rutherfurd made an important observation. He noticed that "if a good prism which with a high power refuses to define the soda line (a more stringent test than solar lines) is violently shaken and then placed in position, it will for a few minutes define beautifully but gradually settle into its former condition."† It occurred to Dr. Draper therefore, that possibly the striæ caused by convection currents produced by inequalities of temperature, and which caused the bad definition, might be destroyed by an active agitation of the liquid. Acting on this suggestion, on the 19th of November 1881 he placed a small propeller wheel in the bisulphide contained in the Thollon prism, its shaft passing out through the stopper. By means of a small electric motor, this propeller could be rotated with any convenient speed. The result was marvelous; by thus keeping the liquid in agitation all inequalities in its density were prevented and the definition became excellent. On the 21st of November, with the stirrer revolving five times a second the definition was so perfect that even with a faint flame the sodium line could be seen distinctly reversed. A series of comparisons was now undertaken between the train of Steinheil prisms and

* J. Phys., viii, 73, 1879. C. R., lxxxviii, 80, 82, 1879. † Loc. cit., p. 130.

the Thollon prism as arranged with the stirrer. On December 2d, using sunlight, the relative dispersion of the two was found to be very nearly equal, the flint train giving perhaps one-eighth more; but the amount of light transmitted by the bisulphide prism was at least four times and in the region about G eight times as great as that obtained from the Steinheil prisms.

But now another source of error was developed. Although when the propeller was running, the definition of the bisulphide prism was not affected by changes of temperature, yet now, these changes of temperature, by changing the refractive index of the liquid, caused a continual shifting of the position of the lines in the spectrum, either in one direction or the other. It is obvious therefore, that during an exposure of any considerable duration, such as is often necessary with faint spectra, this change of position in the lines due to temperature-change would absolutely destroy the definition on the photographic plate. In the hope of correcting this new difficulty, an even temperature box was constructed about the prism, and was filled with cotton. On the morning of December 8th it was found that the thermometer had fallen during the night 9° F. and that the sodium lines had shifted toward the more refrangible end of the spectrum a distance of 0·75 inch.* A direct experiment, made by placing a thermometer in the bisulphide, showed that for a change of 3·75° F. a change took place in the position of these lines of 0·375 inch. The box containing the prism was then enlarged to 30 inches on a side and a plate of iron 6 inches square was let in to the bottom, and so arranged that it could be heated by a gas flame. Subsequently an iron tube closed at the upper end and nine inches long, was passed through the plate and allowed to project 7 inches into the box. The temperature within was regulated by two compound expansion bars made of strips of vulcanite and brass riveted together and included in the circuit of a battery and an electromagnet so arranged that when the ends of the bars came in contact as the temperature rose, the circuit was closed and the electromagnet turned down the gas. When the temperature fell, the circuit was opened and the gas was again turned on. On the 16th of December, the regulator was adjusted for 77° F., the temperature of the room being 63° F. After four hours the sodium lines ceased to move toward the red, but, until the stirrer was started, the definition was bad and the lines could not be separated. On the morning of December 20th the thermometer in the box had fallen over night from 79° to 65° F. and the sodium lines had receded toward the violet end of the spectrum a distance of 1·375 inches. On turning on the

* These measurements were made by Mr. D. C. Chapman, who at that time was acting as Dr. Draper's assistant.

heat, the prism did not appear to feel the effect for half an hour. Then the lines began to move toward the red end of the spectrum and continued to do so for more than five hours. On turning off the heat, the lines began to recede in half an hour; but although it was again turned on, they did not become stationary for an hour. On the 23d, the even temperature box was enlarged and a second box constructed within it, the space between the two being filled with cotton. On the 29th, the regulator was started at 7 A. M. At 1 P. M. the temperature became stationary at 70° F. and the spectrum remained at rest for two hours. On the morning of January 1st, 1882, the temperature of the box was 54° F., having cooled from 72° F. over night, and the sodium lines had moved a distance of 1·8 inches. From these experiments, the conclusion was reached that if a change of over 10° F. is to be made in the box, it is doubtful whether with this apparatus the spectrum can be made stationary on the same day. The heat was therefore left on over night and the temperature was found to be readily controlled the next day. There were fluctuations of course; but they were not enough to injure the definition if the exposure was not over 15 or 20 minutes. On the 25th of January some changes were made in the heating tube by placing a funnel upon its lower end, by continuing it up through the top of the box and by making an opening on one side of it within the box. A relay was also arranged with a damper so as to close the top of this tube whenever the circuit was broken by the separation of the differential bars in the box, and to open it when the circuit was closed. This relay acted in concert with the electromagnet above mentioned, closing the tube when the gas was turned on and opening it when it was turned off. On lighting the gas jet below the funnel, the heated air rises into the tube and passes into the box through the lateral opening in the tube. When the temperature is reached for which the bars are set, they come in contact and close the circuit. The electromagnet attracts its armature and thus turns down the gas while the relay also closes and thus opens the damper on the top of the tube. The heated air now passes out of the box through the lateral opening until the temperature has fallen sufficiently to separate the expansion bars and open the circuit. No experiments with this apparatus are recorded in the note-books.

On the 27th of December, 1884, the apparatus was put in order and some experiments were made with it for the purpose of testing its efficiency. The automatic arrangement for regulating the heat was easily adjusted and found to work well. The definition of the sodium lines which at first was very bad, became admirable in a few moments after starting the stirrer. On the 30th, the first systematic test was made with it. The

gas was lighted at 9 o'clock, A. M., and at 11 h. 20 m. the temperature of the box was 67·5° F. The cross wires of a small telescope were then set on the less refrangible component of the sodium line. In 15 minutes the other component was on the cross wires, the spectrum having shifted the distance between these sodium lines in this time. The displacement was toward the red, and the prism was rising in temperature. The second similar change in position required also 15 minutes; but the third required 19, the fourth 35 minutes and the fifth 49 minutes. A centigrade thermometer reading to tenths was then placed in the box. At 5 h. 25 m., P. M., this thermometer read 21·3° C. and the cross wires were set on the less refrangible sodium line. In 25 minutes the thermometer read 21·4° C. and the spectrum had moved over a little more than the distance between the components. A second change of this amount required 41 minutes, the thermometer showing no change. At 1 h. 2 m., A. M., the spectrum had again shifted by a distance equal to that between the components of the sodium line, but had required 97 minutes to accomplish it, the thermometer reading 22·3° C. at the beginning and at the close of the experiment. The latter part of the time the spectrum shifted by only the width of one of the components in an hour. In a second experiment, an hour and six minutes was required for this amount of displacement. The thermostat was then left in action over night. At 9 h. 10 m. the next morning the thermometer read 22° C. not having perceptibly changed since the last reading, while the sodium lines had shifted in seven hours by only a little more than the distance between them.

The gas was then turned off and the entire apparatus allowed to remain at rest for several days, the temperature of the box, the position of the sodium lines, and their definition being observed by Mrs. Draper from time to time. The following are the values obtained:

Date.	Time.	Temp. of Room.	Temp. of Box.	Definition.	Displacement.
Dec. 31st.	10 p.m.	68° F.	18·2° C.	Excellent.	1·25 inches.
Jan. 1st.	12 m.	69° F.	18·4° C.	"	1·166 "
"	3 p.m.	68° F.	18·6° C.	"	1·083 "
Jan. 2d.	10:45 a.m.	56° F.	13· ° C.	Good.	2·416 "
Jan. 4th.	12:30 p.m.	50° F.	9·6° C.	Fair	3·583 "
"	4:40 p.m.	"	"	Excellent.	3·583 "
		(*Gas lighted in thermostat.*)			
"	7:30 p.m.	50° F.	15·2° C.	Entirely gone	2·083 "
Jan. 5th.	10:25 a.m.	50° F.	9·4° C.	Excellent.	----
		(*Gas lighted in thermostat.*)			
"	10:30 a.m.	50° F.	10·2° C.	Fair.	----
"	10:45 a.m.	"	10·9° C.	Bad.	----
"	10:55 a.m.	"	12·2° C.	Entirely gone.	----
(Started the motor and in five minutes the definition was good. Put out the gas and a few minutes later stopped the motor. Definition lessened very slowly.)					
"	11:15 a.m.	50° F.	11·2° C.	Entirely gone.	----

The results which have been given in the preceding pages seem to have a two-fold bearing. In the first place they prove that by the simple expedient of stirring the liquid in a prism by means of a propeller or other device so as to keep it in active motion, all striæ due to temperature-changes may be prevented and the definition rendered perfect. Even carbon bisulphide, whose extreme mobility and high expansion-coefficient make it extremely sensitive to variations of temperature, may be made in this way to give the most admirable definition; so complete indeed, that in the spectrum given by such a prism, a fine reversed line has been seen in one of the components of the sodium line. The practical value of this simple device is very considerable. The Thollon bisulphide prism above mentioned while giving seven-eighths as much dispersion as six flint prisms gives four times the light in the entire spectrum and eight times the light in the region near G. For photographic purposes, now that the definition can be made permanently sharp and the shifting prevented, this prism must replace trains of glass prisms, and even gratings unless these are of large size and are used with telescopes of proportionately large apertures.

In the second place this investigation has called attention in a very marked manner to the change in refracting power with change of temperature. This subject has already been discussed with reference to liquids by several authors, especially by Gladstone and Dale* in 1858, and with reference to glass by Mendenhall in 1876,† and Hastings in 1878.‡ Both these physicists confirm the statement of Arago and Neumann that for glass the law is precisely the reverse of that given for liquids, and that the refractive index increases with the temperature. Mendenhall calls attention to the effect of this change upon the determination of the position of spectrum lines, especially with a train of prisms, and suggests that it may account for the discrepancies observed in the values given by different observers for the same line. In the case of the Thollon prism described in this paper, it will be observed that the deviation and consequently the refractive index increases in a very marked manner as the temperature diminishes; confirming Gladstone and Dale's law for carbon bisulphide. When the prism was cooled from 22° C. to 9·6°, the double sodium line moved toward the violet end of the spectrum over a distance of

* Phil. Trans., 1858, 887.

† This Journal, III, xi, 406, May, 1876.

‡ Ibid. III, xv, 269, April, 1878. Hastings calls attention to the new and noteworthy fact, brought out by his results, that the variation in dispersive power attending variation in temperature is relatively enormously greater than that of the refractive power.

3·583 inches.* As Mendenhall has shown that no change takes place in the angle of a glass prism with change of temperature, it follows that the flint glass prisms composing the sides of the Thollon prism change only in their specific refraction with change of temperature. Hence the change of the refractive index observed in this prism as above stated, is a differential result due to the excess of the change in the index of the bisulphide in one direction, over that of the flint glass in the other.

Moreover it has now been most clearly shown that by means of a suitable thermostatic arrangement, it is quite possible to preserve the temperature of the prism so uniform that no material change of position shall take place in the spectrum lines, at least during any reasonable exposure. The numerical results above given prove that in the apparatus as arranged by Dr. Draper the temperature did not vary 0·1° C. for more than seven hours, and that during that time the sodium lines did not change their position by an amount equal to the distance between them. Hence this source of difficulty, hitherto so serious in spectrum photography, especially when the exposure is a long one, is entirely obviated.

These experiments, moreover, confirm the opinion that the irregularities in the bisulphide which are the cause of its bad definition, are produced by an inequality between the temperature of the liquid and that of its enclosing vessel, thus producing convection currents in the liquid. So long as the temperatures of the prism and of its contents rise and fall together, and with the surrounding objects, so long the definition remains perfect, notwithstanding the temperature change. It is only when considerable changes of temperature take place suddenly, that the striæ due to these convection currents appear and spoil the definition. As this is the condition in most working laboratories, the advantages there of a method of completely obviating the evil by agitation enables the experimenter to secure good definition with any changes of temperature. But now these changes of temperature, though they cannot produce bad definition, do cause shifting of the lines. The even temperature box already described cures this trouble completely. When this box has been at a constant temperature for a sufficient time, the definition is good even without the stirrer. Even when the temperature of the box is changing quite rapidly, good definition can be always secured by starting the stirrer.

* In the earlier series of experiments the change in position of the Na lines was very closely 0·1 inch for one degree Fahrenheit. In the later series, it was almost exactly 0·3 inch for one degree Centigrade. The results of the two series cannot be compared together owing to a change in the adjustment of the apparatus during the interval.

It will ever be a source of profound regret to the many friends of Dr. Henry Draper that he did not live to complete the research to which the foregoing investigation was preliminary. With his new and admirably equipped laboratory, and with this powerful and thoroughly corrected photographic spectroscope at his command as one of its first fruits, no one can doubt that he would have secured with it results of the highest value to astronomical, and especially to solar, physics.

ART. XXXVI.—*The Genus* Pyrgulifera *Meek, and its Associates and Congeners;* by CHARLES A. WHITE.

THE molluscan fauna of the Laramie Group of Western North America has a remarkable uniformity of character throughout its known geographical extent, from Mexico to British America, with the important exception of a region lying in Utah and Southwestern Wyoming. The strata of this region are underlaid and overlaid respectively by the equivalents of the same formations which underlie and overlie other parts of the Laramie Group, wherever such contacts are known. They are therefore referred to the Laramie Group although they hold a different molluscan fauna which, in my publications, I have usually designated as the Bear River Laramie, to distinguish it from the fauna of the greater part of that extensive group.

This Bear River Laramie fauna contains not only types of mollusca which are not found in that of the principal part of the Laramie Group, but which are not known among any other North American fauna, either fossil or recent; and, what is still more remarkable, a fauna which nearly approaches it, as regards the types referred to, is now living in Lake Tanganyika, Africa.

The molluscan fauna of this lake, whose waters are almost entirely fresh, has been published by Messrs. S. P. Woodward,* Edgar A. Smith† and H. Crosse.‡ Some of the forms are

* Woodward, S. P. On some new Fresh-water shells from Central Africa. Proc Zool. Soc. Lond., 1859, pp. 348–350, pl. xlvii.

† Smith, Edgar A. Diagnoses of new shells from Lake Tanganyika and East Africa. Ann. and Mag. Nat. Hist., (5) iv, 1880, pp. 425–430. On the shells of Lake Tanganyika and the neighborhood of Ujiji, Central Africa. Proc. Zool. Soc. Lond., 1880, pp. 344–352; pl. xxxi. On a collection of shells from Lakes Tanganyika and Nyassa and other localities in East Africa. Proc. Zool. Soc. Lond., 1881, pp. 276–300, pl. xxxii–xxxiv. Description of two new Species of Shells from Lake Tanganyika. Proc. Zool. Soc. Lond., 1881, pp. 558–561; two wood-cuts.

‡ Crosse, H. Faune malacologique du Lac Tanganyika. Journal de Conch., Paris; April, 1881, pp. 105–139, pl. iv. Supplement à la Faune malacologique de Lac Tanganyika. Same Journal, October, 1881, pp. 277–306.

like those which characterize fresh waters elsewhere, such, for example, as Unio, Planorbis, Limnæa, etc.; and some are of peculiar types belonging to fresh-water families, which types are found only or mainly in Africa. But a remarkable feature of this fauna consists in a few types which are so closely like some that are characteristic of marine faunas as to suggest that they have survived the gradual freshening of the lake from a former condition of marine saltness. Two species of one of the generic forms especially, are so nearly like *Trochus* that if they were found among a marine fauna would doubtless be referred to that genus. Mr. Smith has described these as belonging to a new genus, under the name of *Limnotrochus*. Another species which has much the aspect of a marine shell, is the *Melania* (*Sermyla*) *admirabilis* of Smith; but one of the most interesting generic forms of this Tanganyika fauna is the one to which Mr. Smith gave the subgeneric name of *Paramelania*. He described two species under this name, *P. Damoni* and *P. crassiangulata*; and M. Crosse (loc. cit.) referred an associated species, the *Melania nassa* of Woodward, to the same generic group. These seemed to me to be so closely like the *Pyrgulifera humerosa* of Meek, from the Bear River Laramie beds, that I published a note in Nature* expressing my belief that the African and American forms are congeneric; and I afterward republished that opinion with illustrations of both fossil and recent forms.†

In my article in Nature I also called attention to the similarity of *Melania* (*Sermyla*) *admirabilis* Smith, with *Goniobasis Cleburni* White. I might also have mentioned that the surface markings about the beak and front of *Unio Horei* Smith, also from Lake Tanganyika, are considerably like those of *U. belliplicatus* Meek, of the Bear River Laramie fauna. It thus appears that, including this *Unio*, there are three molluscan types in the Laramie Group which are apparently closely related to forms now living in Lake Tanganyika. The most conspicuous of these is the *Purgulifera* of Meek, of which I regard the *Paramelania* of Smith a synonym.

An interesting paper has lately appeared from the pen of Dr. Leopold Tausch,‡ in which he also places the three Tanganyika forms last referred to, under the genus *Pyrgulifera* of Meek, which genus he regards as nearly related to *Paludomus* Swainson. He also announces the discovery of Meek's type-

* White, C. A. Tanganyika Shells. Nature; vol. xxv, 1882, pp. 101–102.

† White, C. A. New Molluscan Forms from the Laramie and Green River Groups, with discussions of some associated forms heretofore known. Proc. Nat. Mus., vol. v, pp. 94–99. pl. iii. A Review of the Non-Marine Fossil Mollusca of North America. Third Ann. Rep. Director U. S. Geol. Survey, pp. 403–550, pl. 1–32.

‡ Tausch, Dr. Leopold. Ueber einige Conchylien aus dem Tanganyika-See und deren fossile Verwandte. Sitzb. der k. Akad. der Wissensch., Band xc, Juli, 1884, pp. 56–70, plates i and ii.

species, *P. humerosa*, in the Upper Cretaceous fresh-water deposits of Hungary; and describes as new four other species of *Pyrgulifera* which he finds there associated with it. Besides these, he refers the *Melanopsis Pichleri* of Hoernes, the *M. armata* and *M. lyra* of Matheron, and the *Turbo acinosus* of Zekeli, all from the Upper Cretaceous of Europe, to *Pyrgulifera*. Thus, according to Dr. Tausch, there are twelve known species of this genus, nine fossil and three living; the latter in Africa exclusively; the type-species only, in North America; and nine in Europe, including the identified type-species there.

Some doubt may be naturally felt as to the genuineness of the identification of *Pyrgulifera* among the living African fauna, as well as that of *P. humerosa* in the Hungarian Upper Cretaceous; but the identification of both seems to be as complete as such determinations can usually be made by means of the shells alone. If it is permissible to establish genera and species among fossil shells at all, we are entitled to hold those genera and species against anything except proof of error in diagnosis.

Admitting these identifications to be correct, the geographical distribution and chronological range of these shells are quite remarkable. They appear to have all been denizens of fresh, or at most, brackish waters, the geographical range of the faunas of which seems necessarily to be more restricted than that of marine faunas may be. Their distribution is all the more remarkable if Dr. Tausch's identification of *Pyrgulifera humerosa* in Hungarian strata is correct. The genuineness of the generic identification of *Pyrgulifera* in the American and European fossil, and the African living, faunas respectively, receives support from the fact that in each case some of the associated forms are similar. I have already mentioned the close similarity between *Goniobasis Cleburni* of the Laramie Group, and *Melania* (*Sermyla*) *admirabilis* of the Tanganyika fauna. Dr. Tausch also calls attention to the existence of *Fascinella* Stache in the Upper Cretaceous of Hungary, and shows that the Hungarian fossil shell is closely like the one living in Lake Tanganyika which Smith has described under the name of *Syrnolopsis lacustris*.

In North America, *Pyrgulifera humerosa* and its branchiferous associates appear to have been both geographically and chronologically restricted. In fact we yet know nothing of the previous, subsequent or contemporary history of the Bear River Laramie fauna; for its distinguishing types are not found either living, or in Tertiary strata and, as before remarked, they did not extend into the principal portion of the Laramie Group.

The cause of this marked difference between the faunas of the two portions of the Laramie Group I suppose to have been connected with their origin and development in two separate hydrographic basins, which probably existed contemporane-

ously, but separated from each other by a land barrier. I have suggested (loc. cit.) that the molluscan fauna of the greater part of the Laramie Group has descended to the present time through a perpetuation of the outlet drainage of the Laramie sea, now become a part of the Mississippi river system where a large part of the same types still live. The types of the Bear River Laramie fauna have not, as a rule, survived in North America. This I have thought was probably due to a failure of the outlet drainage of the waters in which that fauna lived to become perpetuated, in consequence of some subsequent geological changes, which necessarily destroyed its branchiferous fauna, with its peculiar types.

If we accept such views as this and still admit the real genetic relationship of the American, European and African forms which have been referred to, it is difficult to understand how their wide geographical distribution has been effected, and how they have been perpetuated to the present time. An interesting question for paleontologists to consider also presents itself in this connection, which relates to the assumed equivalency of formations which bear similar faunas. There are other reasons than the similarity of faunas why we should regard the American and Hungarian formations which contain *Pyrgulifera* as of approximately the same geological age. But so far as the Tanganyika shells which resemble the fossil forms referred to are concerned, the living fauna of that lake has an interesting homotaxial relationship with those fossil faunas of Europe and America which contain the shells that have been referred to the genus *Pyrgulifera*.

ART. XXXVII. — *On the occurrence of Native Mercury in the Alluvium in Louisiana;* by ERNEST WILKINSON, Ensign U. S. Navy.

NATIVE mercury has been recently discovered in a locality where its presence has hitherto been unsuspected. At "Cedar Grove" Plantation, in Jefferson Parish, Louisiana, on the west bank of the Mississippi, ten miles above New Orleans, native mercury occurs in small globules disseminated through the alluvial soil. These globules vary in size from a microscopic pellet to a BB shot, used for sporting purposes. They seem to be thoroughly admixed in the soil, and although more abundant within a limited area, are found for a distance of 1,200 feet. Beyond this distance, the limited time at my disposal did not allow me to investigate, but the appearance of the soil seems to indicate that the metal is gathered around a

certain center and gradually disappears as the distance from this center increases.

The apparent center lies about 300 feet from the Mississippi River in an orange orchard, where also a number of live oaks are in luxuriant growth. The presence of this mercury has been noticed for a number of years, during the operations of plowing and ditching, but has never, to the writer's knowledge, been officially reported to the scientific world.

The writer took two negro men, with spades, to the locality and obtained several specimens of the soil one to five feet below the surface. He also washed out on the spot, from a small wash-tub full of earth, about two or three ounces of the native element. An analysis of two triturated specimens of the half-dried earth was made with the following results:

1. Weight of soil,	500 grms.	Wt. Hg,	1·4652 grms.		%0·0029+
2. " "	500 "	"	1·4687 "		0·0029+
Total,	1 kilogram.	Total,	2·9339	mean,	%0·002934

Giving a mean percentage of mercury of 0·002934 per cent.

The soil is all alluvial and for a depth of 25 feet is as follows:—

1. Surface, mercury-bearing stratum, six feet thick. A sandy soil containing blue clay and vegetable mould.
2. Stratum of blue clay 6½ feet thick.
3. Similar stratum to surface, but containing no mercury, six feet thick.
4. Stratum of blue clay 6½+ feet thick.

It is not known how much deeper the fourth stratum extends. In none but the upper stratum of alluvial soil does mercury occur in sufficient quantity to be perceptible to the naked eye.

The large quantity of mercury, the great area over which it is scattered, the situation *above* the most frequented resort of commerce, the protection from overflowing by levees, and the absence of any appearance or history of any large cargo of mercury being wrecked in that vicinity, make it extremely improbable that such results could have been effected by the agency of man.

ART. XXXVIII.—*The Earthquakes in Spain;* by C. G. ROCKWOOD, JR.

THE series of earthquakes which has recently devastated the southern part of Spain, began with a disastrous shock at 8^h 53^m P. M., on December 25, 1884.

It had been preceded by a light, but somewhat widely extended shock in the early morning of December 22, which was felt on the northwest coast of Spain and in Portugal, and reached so far under the Atlantic Ocean as to affect Madeira and the Azores. The shock of December 25, has also been followed by a long series of oscillations, repeated at first several times a day, during the rest of December, and with gradually diminishing frequency through the months of January and February, 1885.

The shock on the evening of Christmas day, much the most violent of the series, caused great loss of life and destruction of property. Its influence was plainly felt as far north as Madrid, where bells were rung and clocks stopped, and very slightly also in England; but it was in the southern provinces of Spain, bordering on the Mediterranean Sea, that the greatest damage occurred. In Cadiz, Seville, Cordova, Jaen, and Almeria it was strongly felt, although causing no very serious damage in these places; but within the area defined by this chain of cities and the Mediterranean Sea, many towns and villages were left in a more or less ruined condition. In Granada, of the 10,000 houses composing the city, at least 7,000 will need repairs. The façade of the cathedral was injured. The inhabitants left their homes by thousands, and either camped for days in the open fields or emigrated from the city entirely. The famous Alhambra fortunately escaped injury. The villages of Arenas del Rey, Albuñuelas, Santa Cruz, Zaffaraya, and Alhama were destroyed. The latter place was built partly upon and partly at the foot of a bluff, and the upper town was shaken down upon the lower, overwhelming 1000 houses and 350 of the inhabitants. Here also the hot springs ceased to flow, and after two days began again with increased quantity and augmented temperature, the waters also having acquired a sulphurous character which they had not before possessed.

In Malaga all the public buildings were more or less injured. At Estepona a church and buildings were thrown down. At Torrox twenty-six shocks occurred between 8^h 50^m P. M. of the 25th and 11^h A. M. of the 26th, completely destroying the town. At Nerja the first shocks were followed by a hurricane which

blew down many of the already weakened houses. At Almuñecar twelve shocks occurred in fifteen minutes. At Periana, a landslip overwhelmed a large part of the town, destroying a church and 750 houses. At Guevejar, a great semi-circular crevasse has surrounded the town on its upper side and the village, which rests on clay strata, is slowly sliding downward to the bed of the river Cogollos, some of the houses having already moved 27 meters up to January 16.

The provinces of Granada and Malaga have thus been the scene of the greatest destruction. Official reports up to January 14, state the number of persons injured in Granada as 695 killed and 1480 wounded. Other accounts estimate the entire loss of life as upwards of 2000. Thirty-five villages are named where a greater or less number of victims were taken from the ruins.

As bearing on the possible connection of earthquakes with atmospheric phenomena it is noted that an unusually high atmospheric pressure prevailed over the Spanish peninsula during the first-half of December, while on December 20, a heavy storm, attended by unusual depression of the barometer, struck the northern coast, and passing southward, reached the Mediterranean Sea on December 22, just previous to the great earthquake.

The geological relations of this earthquake may be seen from the following extract from remarks of Mr. J. MacPherson to the Spanish Natural History Society, reported in Nature (vol. xxxi, p. 278).

"A study of the Mediterranean watershed of Andalusia will show the existence of two great mountain masses, chiefly formed of archaic deposits. One of these is known by the name of the Serrania de Ronda, and the other by that of the Sierra Nevada. Both run in a series of folds and faults from southwest to northeast, and between them there lies an interval filled up with palæozoic, secondary and tertiary deposits. Toward the middle of this interval there rises up like an island in the midst of these later deposits, a series of ridges running from northwest to southeast, and formed of archaic rocks. They are known by names of the Sierra Tejea and Sierra Almijara, and the folds of these ranges, as in the case of the other archaic formations, run from southwest to northeast. It is clear, therefore, that this intermediary mountain mass is a segment of a more considerable archaic formation, separated from adjacent rocks through the subsidence of the ground on both sides. Owing to constant oscillations, this detached portion has been covered with the thick mantle of sediment which now overlies it, and its structure is easily accounted for as the result of that great fracture which crosses the peninsula from northwest to southeast, and in the prolongation of which lies the region now described. . . . . .

" . . . The most violent shocks of the earthquake of December 25, were experienced in the region intervening between the Sierra Nevada and the Serrania de Ronda, and precisely on the very belt which enclosed the archaic mass of the Sierras Tejea and Almijara. That part of Andalusia, broken and torn by the secular disturbances of our globe, has proved naturally the weakest, and has, therefore, been the most exposed to the shocks from which Andalusia has so terribly suffered."

The Spanish government has appointed a commission, under the presidency of Sr. D. Manuel Fernandez de Castro, to study the phenomena of this series of earthquakes; and the Paris Academy of Sciences has also sent out a commission on a similar errand, under the lead of M. Fouqué, Professor of Geology in the Collége de France. The former has already issued an exhaustive list of questions, and most interesting and valuable results may be expected from the labors of these commissions.

Princeton, N. J., March 6, 1885.

ART. XXXIX.—*On Devonian Spores;* by J. M. CLARKE.

THE name *Sporangites Huronensis* was proposed by Sir J. W. Dawson in this Journal, April, 1871, p. 257, for minute, flattened, disc-like bodies occurring in abundance in the bituminous shales of Kettle Point, Lake Huron, rocks then regarded by Dr. Dawson of the age of the Marcellus epoch of New York, but referred to the "Upper Devonian" by Orton (this Journal, 1882, vol. xxiv, p. 174). These bodies were looked upon as spores or spore-cases of *terrestrial* acrogens, and this name has been applied to all such spore-like bodies wherever noticed in the Devonian rocks of North America.

Professor Edward Orton has noticed the occurrence of the same in the Devonian and Sub-carboniferous rocks of Ohio ("A Source of the Bituminous Matter in the Devonian and Sub-carboniferous Black Shales of Ohio," loc. cit., p. 171).

Professor H. S. Williams reports similar bodies from the Hamilton Shales of New York (quoted by Dawson, Proc. Am. Ass. Adv. Sci., 1883, "On Rhizocarps in the Palæozoic Period.") They are also found to be common in the black shales of the Marcellus and Genesee epochs in Ontario and adjoining counties of New York.

Dr. Dawson, in 1871 (op. cit.), suggested that these bodies were the fruit of Lepidodendron, possibly of the species *L. Gaspianum* and *L. Veltheimianum*, which occur at the same horizon. Professor Williams's specimens were associated with

the plant *Ptilophyton Vanuxemii.* Dr. Dawson also mentions "rounded spore-like bodies in association with the stems of *Trochophyllum* of Lesquereux, from the lower Carboniferous of Pennsylvania." In the Marcellus beds of Ontario county they occur with *Psilophyton* sp., and in the Genesee Shales with *Cyclostigma affine* Dn. and *Lepidodendron Gaspianum* Dn. From my observations, however, plant remains in rocks containing *Sporangites Huronensis* are extremely rare, the fossils usually accompanying them being invertebrate marine species.

At the Minneapolis meeting of the A. A. A. S., 1883, Dr. Dawson, in the article already referred to, viz: "On Rhizocarps in the Palæozoic Period," suggested the probability of the spores or spore-cases representing the species *Sporangites Huronensis*, having been the fruit of some acrogenous plant of aquatic habit allied to the *Salvinia natans* of European rivers, and following this described forms accompanied and contained by spore-cases, for which was erected the provisional genus *Protosalvinia* with two species, *P. Braziliensis* and *P. bilobata.*

These species were found in material collected by Mr. Orville Derby, of the Geological Survey of Brazil, and are reported to be associated with the fucoid plant Spirophyton.

The reasons for the new interpretation of the relations of these bodies were (1) the occurrence of aquatic invertebrate fossils more or less abundantly in beds containing spores; (2) the existence of sporocarps containing spores and their close similarity to those of the existing Rhizocarps represented by *Salvinia natans* and others.

Of the vegetative portions of the plants producing these spores nothing is positively known. Dr. Dawson has given reasons for believing the species of Ptilophyton to have been aquatic in habit, and allied in fructification to the Rhizocarps.

During a series of years many specimens of Devonian rocks bearing spores have come into my hands from the Corniferous, Marcellus and Genesee horizons in the county of Ontario, N. Y. In the bituminous shales of the Marcellus and Genesee these are usually flattened, similar in mode of preservation to the specimens described by Orton from Kingsville, Ashtabula county, Ohio, and by Dawson from Kettle Point. The calcareous beds of the Corniferous and Marcellus preserve the spores with but little or no distortion, and specimens recently discovered in the latter horizon retain both macrospores and microspores, free and scattered, or within their sporocarps, conserving also the structure of both sporocarps and spores in a favorable condition. I have prepared this brief paper in order to show the structure of these bodies, and for present

purposes they may be divided into *flattened* and *unflattened* spores, as only the latter show traces of structure.

FLATTENED SPORES.—*Sporangites Huronensis* Dawson.

In the Genesee rocks the spores, as far as observed, are always in this condition, but are not common. The bituminous shales of the Marcellus are often crowded with masses of spores of the same size and appearance as those of the Genesee. In their flattened condition they measure about one-third of a millimeter across, in substance consisting of a thin black carbonaceous film, which, by transmitted light, is of a deep orange hue. Specimens from Ohio, kindly sent me by Professor Orton, are similar in shape but somewhat larger and of a light amber yellow. Dawson's specimens from Kettle Point were also of a light yellow. These bodies, as well as those belonging to the first two of the subdivision following, I should regard as macrospores and not as sporocarps.

UNFLATTENED SPORES.

These divide themselves into three groups.

1. *Sporangites Huronensis* Dawson.

Occur in the Marcellus Shales in association with the flattened spores mentioned above. External coat thin, black, showing no structure. Interior filled with clear crystalline calcite, which, in the thin slices, shows strikingly against the black background of bituminous mud. These are very abundant in certain localities, markedly so in the loose bowlders of the Marcellus shaly limestones scattered through the towns of Canandaigua and East Bloomfield, and especially common in the Woodlawn Cemetery in the former place. At but one spot, viz: Padelford's, in the township of Canandaigua, on the N. Y. C. R. R., have rocks been found *in situ* which bear these spores, and there only sparsely. With them occur the fossils, *Leiorhynchus limitaris* Vanux., *Chonetes mucronata* H., *Productella truncota* H., *Leiopteria laevis* H. (Goldfs.?), the characteristic invertebrate fossils of these rocks, and the only plant known here is *Psilophyton*.

2. *Sporangites Huronensis?*

In the loose bowlders from the Corniferous limestone on Mud Creek in the town of East Bloomfield, occur spores which preserve a thick dense outer coating not resolvable into distinct cells. In the slices this external wall seems densest at the periphery and on the interior surface, on both surfaces limited by a black carbonaceous line. Between the two surfaces the

substance is compact and has a granular appearance. The external wall has one third the thickness of the spore. The interior cavity is filled with crystalline calcite. In association with these are many somewhat smaller and often slightly flattened spores, from which most of the external wall has been removed, leaving only a single thin carbonaceous layer. Many of these forms, which seem to have lost most of the external wall, show, in the interior filling of calcite, splotches or filaments of bituminous matter, remnants of the organic substance with which the cavity was originally filled. Usually at a nucleus-like spot at or near the center, the calcite has, in crystallizing, oriented itself differently from that of the surrounding space, which leaves the impression that this spot may represent the original internal cavity of the spore. These bodies measure from one-third to one-half a millimeter in diameter, and are all macrospores. No microspores have been found and no satisfactory evidence as yet of sporocarps.

3. *Sporangites* (*Protosalvinia*) *bilobata* Dawson, 1883.

"Sporocarps, oval or reniform, three millimeters to six millimeters in diameter, each showing two rounded prominences at the ends, with a depression in the middle, and sometimes a raised neck or isthmus at one side connecting the prominences. Some of the specimens indicate that each prominence or tubercle contained several macrospores. At first sight it would be easy to mistake these bodies for valves of *Beyrichia*."—Dawson, *op. cit.*

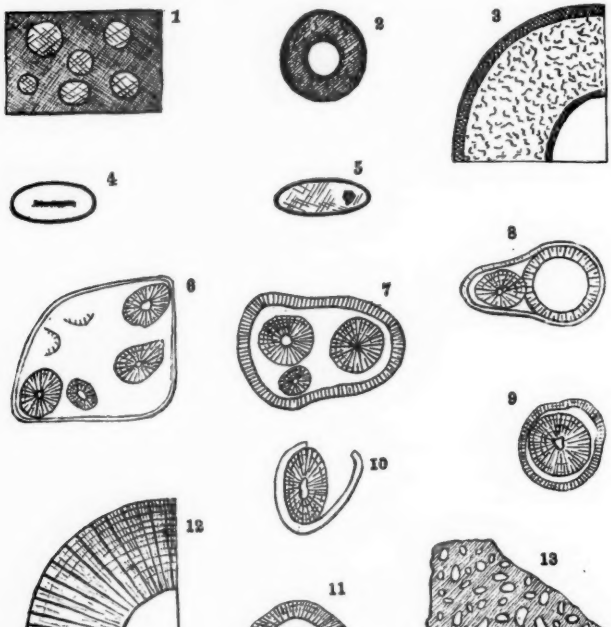
From an examination of scores of slices of the rock containing these bodies, I find that they occur alone, that is unmixed, with the forms already described, and as far as observed, without other fossils.

Sporocarps.—These measure from two-thirds to one millimeter in greatest diameter, being thus considerably smaller than Dr. Dawson's specimens. In general contour and outline they are so strongly suggestive of Beyrichia or Primitia as certainly to mislead in macroscopic characters.

A single deep pit situated usually medially and slightly to one side divides the body into two prominences, which are slightly unequal. The larger of these may have on one side a smaller and shallower depression, making thus the number of prominences sometimes three. As far as observed, opposite sides are symmetrical in the number and position of the tubercles, and they seem to correspond to the macrospores contained within.

The substance of the sporocarps is carbonaceous, made up of minute, densely set, hexagonal cells, which, on the surface, appear as hexagonal pittings and in section as transverse

vertical bars. The rock shows as many empty spore cases as filled, and dehiscence seems to have taken place, along a line which would compare to the "hinge" of a Beyrichia. The sporocarps (in section) contain usually two macrospores, sometimes three, and rarely four or more. Dr. Dawson has not noted the cellular structure in his characterization of this species, but has mentioned it as a feature of his species, Sp. (*Protosalvinia*) *Braziliensis.*



Macrospores.—Usually free and so abundant as to make up the principal portion of the rock. In form spherical or ovoid, in size varying from one-fourth to one-half a millimeter in diameter. The surface is slightly papillose, wall thick and made up of radiating vertical fibers. These are sometimes seen to extend to the center (probably where the section does not pass the axis of the spore), but usually there is a vacant space about the center filled with crystalline calcite. This structure suggests that of the bodies known as *Aetheotesta* Brongniart. The radiating fibres are equally marked in

both. My specimens lack, however, the granular nucleus of *Aetheotesta* and are very much smaller. In a few individuals I have noticed what appears to be a tubular opening through the wall of the spore into the interior cavity.

Microspores.—Less abundant than the macrospores are minute bodies associated with them and measuring from one-eighth to one-twentieth millimeter in diameter. These are round or irregularly oval in section, enveloped by a carbonaceous coat, but showing no structure. I have found no cases containing them, though it may be that some of the empty cases to be found originally enclosed them. These microspores do not, however, seem to be mixed indefinitely with the macrospores, but are generally in little clusters or masses by themselves.

These bodies are known as yet only from bowlders of Marcellus age, which are found in the township of Hopewell, N. Y. Notwithstanding the great difference in the size of these sporocarps and those of *Protasalvinia bilobata* the close agreement in more essential features will justify our regarding these as the North American representatives of the Brazilian type.

Explanation of Figures.

1. *Sporangites Huronensis* Dawson.—Preserving a thin carbonaceous outer wall and filled with calcite. Enlarged 10 diameters. From the Marcellus shales, Canandaigua, N. Y.

2. *Sporangites Huronensis?* Dawson.—Showing the dense wall with thicker exterior and interior layers. Interior filled with calcite. Enlarged 20 diameters. From the Cornifcrous Limestone, Mud Creek, Ontario county.

3. Section of the same enlarged to show the structure.

4. A somewhat flattened individual of the same, preserving only the dense exterior layer, and a carbonaceous mass at the center. This is the usual condition of preservation when a portion of the wall has been removed. Enlarged 20 diameters.

5. An individual of the same, showing the nucleus-like crystallization of calcite in what may have been the original interior cavity. Enlarged 20 diameters.

6. *Sporangites* (*Protosalvinia*) *bilobata* Dawson.—A sporocarp containing four macrospores and showing traces of two more. The structure of the sporocarp is not well preserved. Enlarged 20 diameters. From the calcareous layers of the Marcellus epoch, in the town of Hopewell, Ontario county.

7. A sporocarp of the same, showing its structure and containing three macrospores. Enlarged 20 diameters.

8. The same, with two macrospores. Enlarged 20 diameters.

9. The same, with but one macrospore. Such forms as this may be cross-sections of sporocarps containing more than a single spore. Enlarged 20 diameters.

10. A similar section, showing a dehiscent sporocarp. Enlarged 20 diameters.

11. A macrospore somewhat compressed and showing an apparent opening to the interior cavity. Enlarged 20 diameters.

12. A section of a macrospore enlarged to show the structure.

13. Microspores of this species. Enlarged 20 diameters.

ART. XL.—*Denudation of the two Americas;** by T. MELLARD READE, C.E., F.G.S.

INTRODUCTION.

WHEN in 1876 I had the honor to deliver a Presidential address to this Society I chose as its subject matter "Geological Time," I then had the pleasure to lay before you some calculations relating to "Chemical Denudation" which at the time possessed some little novelty. Since the information was published, it has to a certain extent been incorporated with geological literature. The subject was, however, far from being exhausted, nor is it likely to be so for many years yet to come.

In the meantime, having accumulated additional facts, it will be part of the object of this address to arrange and analyze them, so as to check the original generalizations and further to illustrate the value in geological speculation of an accurate knowledge of the relative magnitude of the various objects and things dealt with.

My former calculations dealt almost exclusively with the amount of matter annually removed in river water from the surface of England and Wales, and from some of the river basins of Europe. I now propose laying before you calculations of a similar nature relating to some of the larger rivers of the two Americas. This done we shall be able to take a wider survey of the subject, and to ascertain how far the provisional generalizations to which previous investigations led are confirmed or otherwise by the greater experience since gained.

THE MISSISSIPPI.

First then we will see what the Father of Waters, the Mississippi, tells us. I may observe that for a long while I found great difficulty in obtaining answers to my various questionings. Years elapsed and letters innumerable were written before I could alight upon any analyses of the waters of the Mississippi, reliable or otherwise. At last through the kindness of Prof. J. W. Spencer, of the State University of Missouri, I was supplied with the following analysis:

Analysis of Mississippi water near Carrolton, a few miles above New Orleans:†

* Substance of Presidential Address to the Liverpool Geological Society, Session 1884–5. Communicated by the author.

† Avequin, Journ. Pharm. [3], xxxvii, p. 258, 1857.

IN A GALLON (56,000 GRAINS).

	Grains.
Potash sulphate, " chloride, Calcium chloride,	3·154
Silica,	2·455
Alumina,	1·753
Calcium carbonate, Magnesium "	7·307
Organic matter,	0·818
Total solid residue,	15·487

According to this analysis the proportion of total solids in solution is by weight $\frac{1}{3615}$. If we take the mean annual discharge of the Mississippi at 541,666,666,666 tons* in round figures, there are 150 million tons of solids in solution per annum poured into the Gulf of Mexico by the Mississippi, a truly remarkable quantity, which if reduced to rock at 15 feet to the ton is represented in round numbers by 80 square miles, 1 foot thick. According to Messrs. Humphreys and Abbot the proportion of sedimentary matter to the water by weight is $\frac{1}{1600}$ and the total discharge of matters in suspension excluding the three outlet bayous is according to them 362,723,214 tons.

The amount of matters in solution vary within certain limits in river water according to the time the samples are taken. There are in some rivers, the Nile for instance, seasonal variations, and doubtless a river with many affluents, traversing strata of various degrees of solubility, must vary in the chemical composition of its waters according as the flood may come from one or the other tributary basin.

If we take the drainage area of the Mississippi proper at 1,214,000 square miles, the calculated amount of solids in solution, according to the analysis, will be 120 tons, removed from each square mile of surface per annum. From the surface of England and Wales I have shown that 143·5 tons per annum are removed in solution† and from the Danube basin 90 tons,‡ so that this is a mean and probably correct.

It has been estimated that the basin of the Mississippi is lowered at the rate of one foot in 6,000† years, but this rate has been calculated from the removal of sediment alone; § if we add to the matter removed mechanically that in solution it will raise the rate to one foot in 4,500 years.‖ What stronger evi-

* Report of Humphreys and Abbott, (1876), p. 146, 19,500,000,000,000 cubic feet at 36 feet to the ton.

† Geikie, Text book of Geology, p. 444. ‡ Chemical Denudation, p. 20.

§ According to the figures I have taken it would be one foot in 6,375 years.

‖ This is estimated as follows: Drainage area 1,244,000 square miles, annual sedimentary discharge from the same area 362,723,214 tons, solids in solution 150,000,000 tons, the average rock estimated at 15 feet to the ton. Strictly speaking, to this should be added 750,000,000 cubic feet of matter, estimated to be pushed along the bottom and the discharge from the bayous. For simplicity's sake I omit these elements.

dence can we have of the importance of chemical action in geological investigation; an importance that has hitherto been strangely overlooked.

Not less surprising considering the apparent insolubility of silica by ordinary agencies* is the fact that in round numbers from 23,000,000 to 24,000,000 tons of silica are poured into the sea annually by this river, while there are 70,000,000 tons of carbonate of lime and magnesia. There is also an exceptional quantity of alumina and a low percentage of sulphates in this water.

The River Plate or Rio de la Plata.

The next river I shall deal with is the Rio de la Plata—the second greatest river of the South American continent. I am indebted to the very exhaustive series of observations and analyses of the waters of the river contained in the report to the Commission of running waters of the City of Buenos Ayres by Juan J. J. Kyle in 1872 and 1874,† for most of the information relating to this river.

I find that the mean of 14 analyses of water taken at different times (April, May and June) in the neighborhood of and above the City of Buenos Ayres gives a proportion of $\frac{1}{6443}$ of solids in solution, which, taking the dry weather flow of the La Plata at 670,000 cubic feet per second‡ (Bateman), will equal 2·8886 tons per second or 91,000,000 tons per annum in round figures.

The dry weather flow of the La Plata equals the *mean* annual flow of the Mississippi. The mean annual flow of the La Plata is not known but it must be greatly in excess of the dry weather flow and sufficient to bring up the total amount of dissolved matter to above that of the Mississippi though it appears from the analysis to have a less percentage of mineral matters in its waters than has the Mississippi. It appears from the report of 1874 that in two analyses of the La Plata water in September 15th and 18th, the matter in solution reached a proportion of $\frac{1}{3125}$. According to an analysis of the waters of the Paraná supplied me by Dr. Frankland§ they contained a proportion of only $\frac{1}{9926}$ of solids in solution. Mr. Juan Kyle states that there is very little difference between the waters of the La Plata taken at 850 m. from the shore and the waters of the Paraná de los Palmas. As the Paraná supplied, according to careful measure-

* Mr. M. E. Wadsworth has shown that ordinary atmospheric agencies produce a greater effect upon rocks of a siliceous character than is generally believed. See this Journal, Dec. 1884, p. 466.

† I must here express my thanks to Mr. J. E. Hawkes for his valuable assistance in translating the pamphlet for me.

‡ See Chemical Denudation, p. 55.

§ See Chemical Denudation, p. 23. 10·08 parts per 100,000.

ment by Mr. Bateman, 520,000 cubic feet of water to the La Plata, while the Uruguay was estimated at only 150,000 cubic feet at the same time, it follows that the chemical constituents of the water of the La Plata must vary considerably at different times and seasons. Probably the analysis on which I have made my calculations will represent a fair annual mean of the solids in solution.

The estimated drainage area of these two rivers is 1,250,000 square miles, so that were the mean annual discharge known it would probably turn out that the greater discharge of the La Plata would more than compensate for the smaller per centage of dissolved matters in its waters and bring the chemical denudation per square mile of river basin up to or beyond that of the Mississippi.

The observations of Mr. Bateman were taken in the month of December, 1870, when the river was at its lowest state. "A continuous drought of six or seven months having diminished the ordinary sources of supply and the periodical rise from the Andes not having commenced." It is difficult, nay, impossible, to predict the mean delivery from the dry weather flow, but the mean flow of the Rhine is given by Beardmore as over twice, the Rhone at Avignon nearly three times, and the Nile at Cairo over seven times the ordinary summer flow.

The waters of the La Plata are distinguished by the fineness of the matter held in suspension; this consists, according to Mr. Kyle, principally of clay. This clay continues a long time in suspension even after filtering. It will pass through the pores of the best filtering papers, the water preserving its turbidity even after months of repose. This is a feature according to Mr. Kyle which is common to all waters that are weakly alkaline. Several chemicals added to the water will, however, precipitate the solid matter by making the muddy particles coagulate into larger compound particles. Chloride of calcium in the proportion of 1 to 5,000 parts will act in this manner. The analyses given by Mr. Kyle are of the water after 48 hours subsidence, so that the unprecipitated matter is included in the solids in solution. The matters in suspension, as is the case with other rivers, vary much according to the state of the river and the water is more impure near the shore than at 850 m. distant.

It is pretty well known that an admixture of seawater with turbid fresh water tends to hasten the precipitation of the solid matters* but it is very probable, as will be seen before I conclude, that the extremely divided solid matter will be carried far and wide by oceanic currents before it can settle to the bottom.

* See "precipitation of Clay in fresh and salt water," by D. Robertson, Trans. Glasgow Geol. Soc., vol. iv, Part III, page 257.

The annual amounts of solids in suspension in the La Plata waters has never to my knowledge been determined or even approximately estimated.

The St. Lawrence.

The next river on the American Continent of which we have any knowledge worth speaking of is the St. Lawrence. The elements for a calculation such as I wish to make are however unfortunately rather vague. Even the area of its basin is stated differently by different authors. According to Guyot* its basin, including, I presume, the area of its immense lakes, is two-fifths that of the Mississippi, while it is said to pour into the sea more than twice its volume. This must, however, be an error, for it would give 40 inches of rain run off the area per annum, whereas, according to the Rainfall Map of the World, prepared by Loomis (this Journal, vol. xxv, p. 88, January, 1883) the whole basin lies in the area of rainfall of from 25 to 50 inches. If we were to take it at 20 inches run off the ground per annum, or half the stated delivery, after deducting the area of the great lakes, the chemical denudation would still be enormously great. The only analysis I have met with gives the proportion of solids in solution at $\frac{1}{6230}$† so that the denudation would amount to, at that rate, over 200 tons per square mile per annum. The one thing probable, however, is, that the matter removed in solution is more per square mile than in the Mississippi basin. The matter removed to the sea in suspension must be comparatively small from the clearness of the water due to its passing through the great lakes.

The Amazons.

The River Amazons is compared by Agassiz in its main features to the Mississippi, inasmuch as it lies in a Cretaceous basin.‡ I think, however, the analogy is a fanciful one. The valley of the Amazons is distinguished from other river valleys by its immense extent, the drainage basin being estimated by Humboldt at over 3 million square miles. The basin appears to have existed much in its present form before it became partially filled with the remarkable deposits of red sandstones and clays covering an immense area which the river is now engaged in rapidly removing to the sea. The upland portions of the basin are largely composed of the granitic and crystalline rocks which are so prominent a feature in the Brazils. The sandstones and clays that have so large a development over the bottom of the basin appear to be Post-tertiary and laid down by the river itself in more ancient times. There are, however,

* Physical Geography. † 16·05 per 100,000 parts, Jahresbericht der Chemie.
‡ Geological sketches—Physical History of the Valley of the Amazons, p. 171.

Tertiary rocks in a part of the basin* possessing an estuarine character in addition to Cretaceous rocks, while on the flanks of the Andes draining into the river are found both cretaceous and Carboniferous rocks. The larger area of the basin appears, however, to be occupied by crystalline rocks and the Post-tertiary sandstones and clays; but a very large part of the basin seems never to have been geologically explored. The basin of the Amazons has also the peculiarity of being situated both to the north and south of the equator and in an area of very heavy rainfall. The chart of mean annual rainfall by Loomis before referred to puts it at from 50 to 75 inches for about $\frac{2}{3}$ of its area, the remainder near the Andes being over 75 inches. The volume of water discharged by the river has been estimated at from 2,700,000 to 3,510,000 cubic feet per second. Taking the mean, this would give about 15 inches run off the ground, or 0·25 of the total rainfall if we take it at 60 inches, about the proportion that flows off the Mississippi basin. The mean rainfall of the Mississippi basin is estimated by Messrs. Humphreys and Abbot at 30·4 inches. Probably 60 inches, would represent the mean rainfall of the Amazons basin. For the purposes of this calculation I take the mean discharge at 3,105,000 cubic feet per second, or 86,250 tons=2,719,980,000,000 tons per annum.†

Through the good offices of Mr. E. Edmondson of Messrs. Gunston & Co., of this city, I have obtained a sample of the water of the Amazons, taken in mid-stream between the Narrows and Santarem in June of this year. This sample I submitted to Dr. Pery I. Frankland for analysis with the following result:

PARTS IN 100,000.

Silica	0·98
Iron and alumina	0·38
Carbonate of lime	2·75
Carbonate of magnesia	0·22
Sulphate of magnesia,	0·37
Chlorate of potassium	0·23
Chloride of sodium	0·15
Sulphate of soda	0·13
Organic matter	0·71
Total solids in solution	5·92

* See "On the Tertiary deposits on the Solimoes and Javury Rivers in Brazil by C. Barrington Brown, Quart. Journ. Geol. Soc., 1879," also "Ancient River Deposits of the Amazons," ibid.

† Bates, Naturalist on the Amazons, vol. i, page 237, says: Von Martius estimates the volume of water passing through the straits of Obydos at 499,584 cubic feet per second. He arrives at this result by taking the depth in the middle at 60 fathoms and at the sides 20 fathoms, the width is given at 1738 yards. Suspecting some error—as the volume of the La Plata in dry weather exceeds this estimated volume of the Amazons—I have re-calculated the delivery from these elements and find that it cannot be less than 3,000,000 cubic feet per second, but may be more according to the form of the bottom. Our gratitude is due to those who give us the means of checking their results.

This gives a proportion of total solids in solution of $\frac{1}{16.890}$ or 5·1 tons per second.

The total delivery of matters in solution will amount, according to these data, to 160,833,600 tons per annum, or, if we estimate the basin at 3,000,000 square miles, to 60 tons per square mile per annum.

It will be observed that the total amount delivered to the sea of solids in solution is not much greater than that we arrived at for the Mississippi. This is a fact worth knowing and due doubtless to the preponderance of gneissic rocks and sandstones and clays of an insoluble character. It is also worth noting that the proportion of silica to the total matter in solution corresponds very closely with that of the Mississippi, amounting to 26,624,481 tons per annum. It is also evident that the rocks and Pampean deposits* occupying the basin of the La Plata are also of a more calcareous and soluble character than the Amazonian Rocks. Not less interesting is it that the carbonate of lime, roughly speaking, is one half of the whole of the solids in solution.†

It follows from these data that the matter removed in suspension must bear an excessive proportion to those in solution as compared to other rivers. The deposits forming the banks of the river are of a loose and friable nature on which the river makes great inroads. The proportion of matters in suspension has never to my knowledge been estimated. Bates, comparing the Pará and the main Amazons, says, "In the former the flow of the tide always creates a strong current upwards, while in the Amazons the turbid flow of the mighty stream over-powers all tides, and produces a constant downward current. The color of the water is different, that of the Pará being of a dingy orange-brown, while that of the Amazons has an ochreous or yellowish clay tint," also "Indeed the fresh water tinges the sea along the shores of Guiana to a distance of nearly 200 miles from the mouth of the river."‡

Inferences and Generalizations.

In my former address I said, "Taking into consideration what we know of the geology of the world, I think we have sufficient grounds for a provisional assumption that about 100 tons of rocky matter are dissolved by rain per English square mile per annum."§ This at the time was considered a very bold statement, but from the data I have laid before you respecting the American continents I venture to think it will be now con-

* See Geological Observations, Darwin, Second Edition, pp. 313 to 369.
† See Chemical Denudation, p. 24. ‡ Naturalist on the Amazons, vol. i, p. 5.
§ Chemical Denudation, p. 24.

sidered as applied to the whole world a very fair approximation.

Let us pause to consider the meaning of all these figures, for unless they have a meaning which the mind and imagination can seize upon, the wearisome labors of collecting the data and making the computations were well nigh wasted.

First, as regards the Mississippi, of which we possess the most reliable particulars.—I have shown that the estimate of the rate of denudation of its basin must be increased in round figures from $\frac{1}{6000}$ to $\frac{1}{4500}$ of a foot per annum* in consequence of the solid matter which is removed in solution. Is it not a striking instance of the little importance attached to chemical denudation as a geological agent, when the matter removed in solution does not enter as an element into the calculations of such an observant reasoner as a Geikie or a Croll. Thus we arrive at the first and not unimportant result which I promised from quantitative examination. Now mark, it is not that geologists were unaware of the effect of chemical action on the rocks. Take up any text-book or manual and you will find a chapter devoted to it and the whole process correctly explained, nevertheless the quantity of matter removed was not realized and never could have been except through laborious calculations. That being done it is easy to see how these great results occur. Examine the hardest rock and you will find it weathered, you will find it coated over with a crust, of a thickness varying with the time its surface has been exposed. This crust is composed of the constituents of the rock that remain after part have been removed by chemical action.† Examine the waste talus from some of the old quarries at Penmaenmawr and you will see that atmospheric agents have in the space of 30 years perceptibly affected a felstone rock that seems at first sight absolutely indestructible.‡ How much more then must they affect rocks of a more friable and soluble nature. I have shown that $\frac{1}{12978}$ of a foot per annum is removed from the surface of England and Wales in a soluble form every year,§ say $\frac{1}{1081}$ of an inch, so that in 30 years it would amount to $\frac{1}{36}$ of an inch.

* This calculation as before explained takes no account of matters pushed along the bottom, they have not been determined with much accuracy and it is probable as Mr. A. Tylor has suggested there is more than has been estimated. This would further reduce the time.

† It is usual to refer this action entirely to the carbonic acid present in the rain water, but Mr. Alexis A. Julien has brought forward a great body of facts to prove that the solvents of the rocks are largely organic acids existing in decaying vegetable matter. "On the geological action of the Humous Acids." Proc. of the American Assoc. for the Advancement of Science, Saratoga meeting, 1879.

‡ This stone is largely used for making "setts" for street paving, sold under the name of "Welsh granite setts," and found to be the most lasting material for the purpose.

§ Chemical Denudation.

This is the mean denudation, but I have also shown that the denudation is very much equalized by the fact of the harder rocks usually occurring in areas of great rainfall.*

It is therefore not unlikely that, if we were to institute accurate experiments over a sufficiently long time, it would turn out that the calculation of the amount of matter removed in solution could be verified by direct tests, and that even these hard rocks would be found to waste at something near the indicated rate. It would appear from the examples of the Mississippi, the Nile and Danube that the matter brought down in solution and suspension is as 1 to 3.

These examples are of rivers where there have been the most accurate and fullest data to judge by. Whether the proportion would be borne out in other river basins we have no very good means of judging; but it would appear that in large rivers the nature of the rocks is so varied, the areas being so extensive, that the relation of the materials in solution to those in suspension have a tendency to keep very constant. It will be seen from a consideration of these facts that matters chemically dissolved in the water must play a much more important *role* in the reconstruction of the earth than was formerly suspected.†

What becomes of all these mineral matters ceaselessly flowing into the sea? It has been shown by Mr. Buchanan‡ that the proportions of mineral matters to each other in sea water is nearly constant everywhere, although there is a variation in different seas in the proportion of total mineral matter in solution to the water it is dissolved in. Nature has achieved a balance of supply and demand. It is also well known that the coarser matters in suspension, unless brought under the influence of a strong current, settle near the mouths of the rivers and then spread themselves by help of tides and winds along the coast and there mingle with the detritus the sea wears away from the coast. The finer particles distribute themselves over a larger area and probably the very finest over the whole sea bottom. In every ocean dredging there is a greater or less amount of argillaceous matter, whether it be in the ooze or the red clay, which I suggest is more likely to be the "dust of continents," than to arise from the disintegration of volcanic matter, such as pumice, but it is no doubt largely mingled with such volcanic matters as Mr. Murray clearly shows. It seems to me rather a far-fetched notion that the winds should contribute dust to the deepest ocean, but that the waters should make no mechanical contribution to the deposit. The bulk of

* Chemical Denudation.

† It is singular that Hutton in his theory of the earth estimates at a gross computation "that the fourth of the solid land is composed of matter which had formed the calcareous tests of animals"

‡ Challenger Reports.

the ocean water is so great as compared to the probable amount of matter in a state of the finest comminution that can get into it, that it might not even be possible to detect its presence in a sample of ocean water. At the same time it might contain quite sufficient to account for much of the argillaceous matter found in the deep ocean soundings. I have shown that the matters in solution in rain waters are, roughly speaking, one quarter of the whole matter in the water in solution and suspension. The finest particles, sufficiently fine to be carried away by oceanic surface currents, such as the Gulf Stream, are probably not in bulk half as great as the matter in solution. If we take as an example the estimate I have given of the chemical denudation of England and Wales it amounts, as I have already shown, to $\frac{1}{3\,6}$ of an inch in 30 years. This would give, supposing the impalpable mud to be worn off at half that rate, 60 years for the denudation of $\frac{1}{3\,6}$ of an inch. The area of the sea to land is roughly as 3 to 1, therefore at this rate it would take 180 years for $\frac{1}{3\,6}$ of an inch of mud converted into rock to accumulate if distributed evenly over the ocean floor. When we consider the average depth of the ocean is over two miles, $\frac{1}{3\,6}$ of an inch distributed through it would amount to no more than about one five-millionth part, and this, be it remembered, has 180 years to accumulate and settle, so that if we give each particle of these fine matters in suspension 10 years to settle to the bottom there would never be in the ocean water at one time more than one ninety-millionth part of matters in suspension, an amount so small as to be practically imperceptible. The probability that such an infinitesimal amount of matter in suspension may be present is still more evident when we find that fine sand floats on the surface of the sea for considerable distances, for Prof. Verrill says that in the course of the Gulf Stream they always take with their towing nets more or less fine siliceous sand* (this Journ., 1882, xxiv, p. 449).

I think it is fairly evident from the foregoing calculations

* Prof. A. E. Verrill also says that, in the Gulf Stream slope examined by us, the bottom in 70 to 300 fathoms, 60 to 120 miles from the shore, is composed mainly of very fine sand, largely quartz, with grains of feldspar, mica, magnetite, &c.; with it there is always a considerable percentage of shells of foraminifera and other calcareous organisms, and also spherical, rod-like and stellate sand-covered rhizopods often in large quantities. In the deeper localities there is usually more or less genuine mud or clay, but this is often almost entirely absent even in 300 to 500 fathoms. The sand however is often so fine as to resemble mud and is frequently so reported when the preliminary soundings are made and recorded." "The prevalence of fine sand along the Gulf Stream slopes in this region and the remarkable absence of actual mud or clay deposits indicate that there is here at the bottom sufficient current to prevent for the most part the deposition of fine argillaceous sediments over the upper portion of the slope in 65 to 150 fathoms. Such materials are probably carried along till they eventually sink into the greater depths nearer the base of the slope, or beyond in the ocean basin itself, where the currents are less active." (This Journal, vol. xxiv, pp. 448–9, 1882.)

that there may be accumulations going on in the great oceans which we can no more see than we can the matters in solution.* It is only because the mineral matters get concentrated in the sea water that they are forced upon our notice. They slowly concentrate until a balance is attained and they are removed from the sea water at the same rate that they are poured into it.

ART. XLI.—*On Arctic Interglacial Periods;* by JAMES CROLL, LL.D., F.R.S.†

POLAR Interglacial Periods more marked than the Glacial.—In a former paper,‡ and also in 'Climate and Time' (chap. xvi), it was pointed out that in temperate regions the cold periods of the Glacial epoch would be far more marked than the warm interglacial periods. In temperate regions the condition of things which prevailed during the cold periods would differ far more widely from that which now prevails than would the condition of things during the warm periods. But as regards the polar regions the reverse would be the case; there the warm interglacial periods would be more marked than the cold periods. The condition of things prevailing in these regions during the warm periods would be in strongest contrast to what now obtains; but this would not hold true in reference to the cold periods, during which matters would be pretty much the same as at present, only somewhat more severe. In short, the glacial state is the normal condition of the polar regions, the interglacial, the abnormal. At present Greenland and other parts of the Arctic regions are almost wholly covered with snow and ice, and, consequently, nearly destitute of vegetable life. In fact, as regards organic life in those regions, matters during the Glacial epoch would not probably be much worse than they are at the present day. Greenland and the Antarctic continent are to-day almost as destitute of plant-life as they could possibly be. Although, in opposition to what is

* Mr. Thomas Higgin, F.L.S., of Anderton Salt Works, Northwich, prepares his finest quality of salt by precipitating the slight proportion of muddy impurities which the cold brine holds in suspension by heating it in large vats. At my suggestion he carried out a series of experiments to determine the proportion of mud so removed. He found that it amounted to 57 lbs per 1,556 tons of brine $=\frac{1}{61\frac{1}{48}}$. Looking at the brine, purified and unpurified together in clean bottles, the difference between them is so faint as to be hardly distinguishable. It of course affects the color of the manufactured salt to a much greater extent both by the higher proportion the impurities bear to the salt and the whiteness of the salt.

† Phil. Mag., Jan., 1885. Communicated by the author.

‡ Phil. Mag., May, 1884, p. 375; this Journal, June, 1884.

found to be true in reference to the temperate regions, the polar interglacial periods were more marked than the glacial, it does not follow that on this account the relics of the interglacial periods which remain ought to be more abundant in polar than in temperate regions. On the contrary, the reverse ought to be the case. In the polar regions, undoubtedly, there is least likelihood of finding traces of interglacial periods; for there, of all other places, the destruction of such traces would be most complete. The more severe the glaciation following a warm period, the more complete would be the removal of the remains belonging to the period. If in such places as Scotland and Scandinavia so little is left of the wreck of interglacial periods, it need be a matter of no surprise that in Arctic regions scarcely a relic of those periods remains. The comparative absence in polar regions of organic remains belonging to a mild interglacial period cannot therefore be adduced as evidence against the probable existence of such a period. Who would expect to find such remains in ice-covered regions like Greenland and Spitzbergen? Although not a trace is now to be found, it is nevertheless quite possible that during interglacial periods those regions may have enjoyed a comparatively mild and equable climate.

Evidence from the Mammoth in Siberia.—This comparative absence of the remains of a warmer condition of climate in Arctic regions during Pleistocene times holds true, however, only in regard to those parts, like Greenland, which have undergone severe glaciation. When we examine Siberia and other places which appear to have escaped the destructive power of the ice, we find, from a class of facts, the physical importance of which appears to have been greatly overlooked, abundant proofs of a mild and equable condition of climate. I refer to facts connected with the climatic condition under which the Siberian Mammoth and his congeners lived. The simple fact that the Mammoth lived in Northern Siberia proves that at the time the climate of that region must have been far different from what it is at the present day.

The opinion was long held, and is still held by some, that the Mammoth did not live in Northern Siberia, where his remains are found, but in more southern latitudes and that these remains were carried down by rivers. It was considered incredible that an animal allied to the Elephant, which now lives only in tropical regions, should have existed under a climate so rigorous as that of Siberia. The opinion that the remains were floated down the Siberian rivers is now, however, abandoned by Russian naturalists and other observers who have carefully examined the country.

I shall here give a brief statement of the facts and arguments which have been adduced in support of the theory that the Mammoth lived and died where its remains were found. For these facts I am mainly indebted to the admirable papers by Mr. Howorth on the Mammoth in Siberia, which appeared in the Geological Magazine for 1880.

Had the remains of the Mammoth been carried down from the far south by the Siberian rivers, they would have been found mainly, if not exclusively, on the banks of the long rivers, such as the Obi, Yenissei and the Lena, and in the deltas formed at their mouths. But such is not the case "These are," says Mr. Howorth, "found even more abundantly on the banks of the very short rivers east of the Lena. They are found not only on the deltas of these rivers, but far away to the north, in the islands of New Siberia, beyond the reach of the currents of the small rivers, whose mouths are opposite those islands." But a more convincing proof is that "they are found not only in North Central Siberia, where the main arteries of the country flow, but in great numbers east of the river Lena, in the vast peninsula of the Chukchi, in the country of the Yukagirs, and in Kamtskatka, where there are no rivers down which they could have floated from more temperate regions." Besides, it is not merely in the deltas and banks of rivers that the remains are found, but in nearly all parts of the open tundra; and Wrangell says* that the best, as well as the greatest number of remains are found at a certain depth below the surface in clay-hills, and more in those of some elevation than along the low coast or in the flat tundra.

Had the Mammoth lived in the south we should, as Mr. Howorth further remarks, have found its remains most abundant in the south, whereas the farther north we go the remains become more abundant, and in the islands of the Liachof archipelago, in about latitude 74°, the greatest quantities have been discovered. Again, according to Hedenstrom, the bones and tusks found in the north are not so large and heavy as those in the south; a fact which still further confirms the opinion that the Mammoth lived where his remains are found, inasmuch as the greater severity of the climate in northern parts would certainly hinder the growth and full development of the animal.

Northern Siberia much warmer during the Mammoth Epoch than now.—It is true that the Mammoth and the *Rhinoceros tichorhinus* were furnished with a woolly covering which would protect them from cold; but it is nevertheless highly improbable that they could have endured a climate so severe as that of Northern Siberia at the present day, where the ground is

* Polar Sea Expedition, English translation, p. 275.

covered with snow for nine months in the year and the temperature is seldom much above zero Fahr. And even if they could have endured the cold, they would have starved for want of food. Some parts of Siberia are no doubt fertile, as, for example, the valley of the Yenisei, described by Nordenskjöld;* but there is little doubt, as Mr. Howorth remarks, that the larger portion of Northern Siberia, where the Mammoth and the Rhinoceros lived, is now a naked tundra covered with moss, on which no tree will grow. On such ground it is physically impossible that the Mammoth and Rhinoceros could exist, for they cannot graze close to ground like oxen. They live on long grass and on the foliage and small branches of trees.

Evidence from Wood.—The fact that the Mammoth was most abundant beyond the present northern limit of wood is pretty good evidence that the climatic condition of Northern Siberia must have been milder than now. Wood must have extended, in the days of the Mammoth, far beyond its present limit, probably as far north as New Siberia: facts of observation support this conclusion.

The wood found in Northern Siberia consists of two classes —the one is the result of drift, the other grew on the spot. The natives call the former "Noashina," and the latter "Adamshina;" and the division is supported by Göppert, "who separates the trunks of timber found in Northern Siberia into a northern series, with narrow rings of annual growth, and a southern, with wider ones. The latter doubtless floated down the rivers, as great quantities do still; while the former probably grew here with the Mammoth."

In the middle of October, 1810, Hedenstrom went across the tundra direct to Ustiansk. "On this occasion," he says, "I observed a remarkable natural phenomenon on the Chastach Lake. This lake is 14 versts long and 6 broad, and every autumn throws up a quantity of bituminous fragments of wood, with which its shores in many places are covered to the depth of more than 2 feet. Among these are pieces of a hard transparent resinous substance, burning like amber, though without its agreeable perfume. It is probably the hardened resin of the larch tree. The Chastach Lake is situated 115 versts from the sea and 80 versts from the nearest forest."†

On the same journey Hedenstrom noticed "on the tundra, equally remote from the present line of forest, among the steep sandy banks of the lakes and rivers, large birch trees, complete, with bark, branches and root. At the first glance they appeared to have been well preserved by the earth; but, on digging them up, they are found to be in a thorough state of decay. On being lighted they glow, but never emit a flame:

* 'Nature,' Dec. 2, 1875. † Wrangell, p. 491.

nevertheless the inhabitants of the neighborhood use them as fuel, and designate these subterranean trees as *Adamoushtshina*, or of Adam's time. The first living birch tree is not found nearer than three degrees to the south, and then only in the form of a shrub."*

On the hills in the interior of the Island of Koteloni "Sannikow found the skulls and bones of horses, buffaloes, oxen and sheep in such abundance that these animals must formerly have lived there in large herds. At present, however, the icy wilderness produces nothing that could afford them nourishment, nor would they be able to endure the climate. Sannikow concludes that a milder climate must formerly have prevailed here, and that these animals may therefore have been contemporary with the Mammoth, whose remains are found in every part of the island."†

"Herr von Ruprecht reported to Brandt that, at the mouth of the Indiga, in 67° 39′ N. lat., on a small peninsula called Chernoi Noss, where at present only very small birch bushes grow, he found rotten birch trunks still standing upright, of the thickness of a man's leg and the height of a man. In going up the river he met with no traces of wood until he reached the port of Indiga. Here he noticed the first light-fir woods growing among still standing but dead trunks. And higher up the river still, the living woods fairly began."‡

Schmidt says that, "where the lakes on the tundra have grown small and shallow, we find on and near their banks a layer of turf, under which, in many places, *are remains of trees in good condition, which support the other proofs that the northern limit of trees has retrogressed, and that the climate here has grown colder.* I found, on the way from Dudino to the Ural Mountains, in a place where larches now only grow in sheltered river-valleys, in turf on the top of the tundra, prostrate larch trees still bearing cones."§

Schmidt also states that he was informed that at Dudino, just at the limit of the woods, there had been found in a miserable larch wood the lower part of a stem sticking in the ground, apparently rooted, which was three feet in diameter. He also states that, "eleven versts above Krestowkoje, in lat. 72°, he found, in a layer of soil covered with clay on the upper edge of the banks of the Yenissei, well-preserved stems like those of the birch, with their bark intact, and sometimes with their roots attached, and three to four inches in diameter. Professor Merklin recognizes them as those of the *Alnaster fruticosus*, which still grows as *a bush* on the islands of the Yenissei, in lat. 70½° N."

* Wrangell, p. 492. † Wrangell, p. 496.
‡ Bull. Soc. Nat. Moscow; quoted by Howorth.
§ Schmidt, as quoted by Howorth.

Evidence from Shells.—In the freshwater deposits in which the bones of the Mammoth are found, there are fresh-water and land-shells, which indicate a warmer condition of climate. I quote the following from Mr. Howorth's memoir:—

"Schmidt found *Helix Schrencki* in fresh-water deposits on the tundra below Dudino and beyond the present range of trees. Lopatim found recent shells of it, with well-preserved colors, 9° farther south, in lat. 68° and 69°, within the present range of trees, at the mouth of the Awamka. The most northern limit hitherto known for this shell was in lat. 60° N., where they were found by Maak in gold-washings on the Pit."

"In the freshwater clay of the tundra by Tolstoi Noss, Schmidt found *Planorbis albus*, *Valvata cristata*, and *Limnæa auricularia* in a sub-fossil state; *Cyclas calyculata* and *Valvata piscinalis* he found thrown up on the banks of the Yenissei, and on a rotten drifted trunk, *Limax agrestis*; *Anodonta anatina* he also found on the banks of the Yenissei as far as Tolstoi Noss, but no farther. *Pisidium fontinale* still lives in the pools on the tundra; as does *Succinea putris* on the branches of the Alnaster on the Brijochof Islands."

Mr. Belt mentions* that the *Cyrena fluminalis* is found in Siberia in the same deposits which contain the remains of the Mammoth and the *Rhinoceros tichorhinus*.

"The evidence, then," says Mr. Howorth, "of the *débris* of vegetation, and of the fresh-water and land-shells found with the Mammoth-remains, amply confirms the *à priori* conclusion that the climate of Northern Siberia was at the epoch of the Mammoth much more temperate than now. It seems that the botanical facies of the district was not unlike that of Southern Siberia, that the larch, the willow, and the Alnaster were probably the prevailing trees, that the limit of woods extended far to the north of its present range and doubtless as far as the Arctic Sea; that not only *the mean temperature was much higher, but it is probable that the winters were of a temperate and not of an Arctic type.*"—Geol. Mag., December, 1880.

The Mammoth Interglacial.—It need be a matter of no surprise that the climate of Northern Siberia during the time of the Mammoth was more mild and equable than now, if we only admit that the Mammoth was interglacial. That it was of interglacial age is a conclusion which, I think, has been well established by Prof. J. Geikie and others. Into the facts and arguments which have been advanced in support of this conclusion I need not here enter. The subject will, however, be found discussed at great length in Prof. Geikie's 'Prehistoric Europe' and in 'The Great Ice-Age' (second edition). Mr. R. A. Wallace considers that one of the last intercalated

* Quart. Journ. Geol. Soc., vol. xxx, p. 464.

mild periods of the Glacial epoch seems to offer all the necessary conditions for the existence of the Mammoth in Siberia. That the Mammoth was interglacial will be further evident when we consider the climatic conditions of Europe at the time that it lived there. Before doing so, it may be as well to glance at what evidently were the main characteristics of the interglacial periods.

Main Characteristics of Interglacial Climate.—They are as follows:

1. Interglacial conditions neither did nor could exist ***simultaneously*** on both hemispheres. They existed only on one hemisphere at a time, viz: on the hemisphere which had its winter solstice in perihelion.

2. During interglacial periods the climate was more *equable* than it is at present; that is to say, the difference between the summer and winter temperatures was much less than it is now. The summers may not have been warmer or even so warm as they are at present, but the temperature of the winters was much above what it is at the present day.

3. During the interglacial periods the quantity of equatorial heat conveyed by ocean-currents into temperate and polar regions was far in excess of what it is at present. On this account a greater *uniformity* of climate then prevailed: that is to say, the difference of climatic conditions between the subtropical and the temperate and polar regions was less marked than at present—the temperature not differing so much with latitude as it now does.

4. *Mildness*, or a comparative absence of high winds, characterized interglacial climate. This partial exemption from high winds resulted from the fact that the difference of temperature between the equator and the poles, the primary cause of the winds, was much less than at the present day.

5. Another character of interglacial climate was a *higher mean temperature* than now prevails. This, amongst other causes, resulted from the great amount of heat then transferred by ocean-currents from the glacial to the interglacial hemisphere.

6. During interglacial periods the climate was not only more equable, mild, and uniform than now, but it was also more *moist*. This was doubtless owing mainly to the fact of the presence then in temperate and polar regions of so large an amount of warm intertropical water. In short, it was the presence of so much warm water from intertropical regions which mainly gave to the climate of the interglacial periods its peculiar character.

All these characteristics of interglacial climate have been fully established by the facts of geology, but they are also, as

we have seen, deducible *à priori* from physical principles. They follow as *necessary consequences* from those physical agencies which brought about the Glacial epoch.

Evidence from the Mammoth in Europe.—Skeletons and detached remains of the Mammoth have been found in nearly every country in Europe. Mr. Howorth in his memoir,* gives the details of the finding of these in various parts of Russia, Germany, Denmark, Sweden, Belgium, France, England, and other countries. It is shown that the conditions under which the Mammoth-remains have been found in Europe are almost identically the same as those under which they are found in Siberia, with the exception, of course, that in Europe no carcasses with their flesh intact have been met with.

Again, the deposit in which the Mammoth-remains are found in Europe is the same as that in which they occur in Siberia. The deposit is a freshwater one, consisting of marly clay and gravel, and containing plant-remains and land- and freshwater-shells. When these plants and shells are examined, they are found to indicate the same interglacial condition of climate as that which prevailed in Siberia during the time the Mammoth lived in that region.

In the case of land-plants it is, of course, only under exceptional circumstances, as Prof. J. Geikie remarks, that they can be found in a condition suitable for the botanist. Now and again, however, beds with well-preserved plants are met with, buried under lacustrine deposits. In a still better state of preservation are the plant-remains and shells which have been discovered in the masses of calcareous tufa which have been formed upon the borders of incrusting springs. An examination of the plant-remains found under these conditions shows that during the Pleistocene times, when the deposits in which the Mammoth bones are found were being formed, the climate was more equable and uniform than it is at the present day.

The fossiliferous remains yielded by the tufas have led to most important results as to the climatic condition of the Pleistocene period, into the details of which I need not here enter. These will be found at full length in Prof. J. Geikie's Prehistoric Europe, chap. iv.† It will suffice at present simply to refer to the general conclusions to which these researches have led, in so far as they bear on the climatic conditions prevailing at the time the Mammoth lived so abundantly in Europe.

In the tufa deposits of Tuscany have been found numbers of plant-remains of indigenous species, commingled with others which now no longer grow in Tuscany. Amongst the latter is the Canary laurel, which now flourishes so luxuriantly in the

* Geol. Mag., May, 1881.

† See also Mr. Howorth's memoir, Geol. Mag., June, 1881.

Canary Islands, on the nothern slopes of the mountains, at an elevation of from 2,000 to 5,000 feet above the sea-level—a region, remarks Prof. J. Geikie, nearly always enveloped in steaming vapors, and exposed to heavy rains in winter. In that deposit is also found the common laurel, associated with the beech. This is not now the case, as the laurel requires more shade than it can find there at the present, while the beech has retreated to the northern flanks of the Apennines to obtain a cooler climate.

In the tufas of Provence are found groups the same as those which flourish there at present, but commingled with them are also the Canary laurel and other plants which are no longer natives of Provence. Saporta directs attention to the fact that species such as the Aleppo pine and the olive, demanding considerable summer-heat rather than a moist climate, are entirely wanting in the tufas.

Similar to those of Provence are the tufas of Montpellier. Saporta concludes that when all those species lived together the climate must necessarily have been *more equable and humid* than at present. In other words, the summers were not so dry and the winters were milder than they are now.

The deposit near Moret, in the valley of the Seine, is still more remarkable in showing the equable condition of climate which than prevailed. The assemblage of plants found there tells a tale, says Prof. J. Geikie, which there is no possibility of misreading. "Here," he says, "we have the clearest evidence of a genial, humid, and equable climate having formerly characterized Northern France. The presence of the laurel, and that variety of it which is most susceptible to cold, shows us that the winters must have been mild, for this plant flowers during that season, and repeated frosts, says Saporta, would prevent it reproducing its kind. It is a mild winter rather than a hot summer which the laurel demands, and the same may be said of the fig-tree. The olive, on the other hand, requires prolonged summer heat to enable it to perform its vital functions. Saporta describes the fig-tree of the La-Celle tufa as closely approximating, in the size and shape of its leaves and fruit, to that of the tufas in the south of France, and to those of Asia Minor, Kurdistan and Armenia. But if the winters in Northern France were formerly mild and genial, the summers were certainly more humid, and probably not so hot. This is proved by the presence of several plants in the tufa of La-Celle which cannot endure a hot arid climate, but abound in the shady woods of Northern France and Germany."

The plants found in the tufas of Canstadt are much similar to those of Moret. Mr. Howorth, in regard to the deposits of those places, says: "The coexistence of the species found there,

remarks M. Saporta, proves very clearly that, notwithstanding the variations due to latitude, Europe, from the Mediterranean to its central districts, offered fewer contrasts, and was more uniform than it is now. A more equable climate, damp and clement, allowed the *Acer pseudo-platanus* and the fig to live associated together near Paris, as it allowed the reindeer and hyæna. The *Acer* grows with difficulty now where the *Ficus* grows wild, while the latter has to be protected in winter in the latitude of Paris."*

Equally conclusive is the testimony borne by the Mollusca of the tufas. In the tufas and marls of Moret, in the valley of the Seine, thirty-five species were discovered. The majority of these must have lived in damp and shady places, in the recesses of moist woods, and on the leaves of marsh-plants. The shells, M. Tournouër concludes, bespeak a condition of climate more uniform, damp, and equable than now prevails in that region, with a somewhat higher mean annual temperature. In the alluvial deposits of Canstadt, in Wurtemberg, a class of shells indicating a similar condition of climate has been discovered.

The evidence furnished by the animals found most abundantly with the Mammoth in Europe and Siberia, Mr. Howorth thinks, points to the same conclusion as that of the plants and mollusca.

The same mild and equable condition which allowed of the Mammoth living in Northern Siberia during Pleistocene times thus equally prevailed over the whole of Europe. We have seen that, according to the Physical theory, this condition of climate was in every respect precisely what it ought to have been on the supposition that it was interglacial. It was a condition mild, equable, uniform, humid, and of a higher mean annual temperature than we have at the present day. There is, however, direct and positive evidence that this condition of climate was interglacial; for the facts both of geology and of paleontology show that it was preceded and succeeded by a state of things of a wholly opposite character.

The Mammoth Glacial as well as Interglacial.—Although the Mammoth could have lived in Arctic Siberia only during an interglacial period, it does not follow that it must have perished during the succeeding glacial period. When the cold came on, and the vegetation on which it subsisted began to disappear, it would move southward, and would continue its march as the cold and severity of the winters increased. During the continuance of the ten or twelve thousand years of Arctic conditions it would find in Southern Europe and elsewhere places where it could exist. At the end of the cold period, and when

* Geol. Mag., June, 1881.

the climate again began to grow mild and equable, it would retrace its steps northward. There is, however, little doubt that during the severity of a glacial period, and when necessarily confined to a more limited area, its numbers would be greatly diminished. There is every reason for believing that the Mammoth outlived all that succession of cold and warm periods known as the Glacial epoch proper, and did not finally disappear till recent post-glacial times.

It was probably about the commencement of a cold period, and before the Mammoth had retreated from Northern Siberia, that those individuals perished whose carcasses have been found frozen in the cliffs. The way in which they probably perished and became imbedded in the frozen ice and mud, has, I think, been ingeniously shown by Dr. Rae.*

Arctic America during Interglacial times.—We have seen that the eastern continent in Pleistocene times enjoyed in the Arctic regions interglacial conditions of climate. It is true that on the western continent we have not in Arctic regions such clear and satisfactory evidence of an interglacial period. But it would be rash to infer from this that the western continent was, in this respect, less favored than the eastern. That we should find less evidence at the present day of former interglacial periods in Arctic America than Arctic Asia, is what is to be expected, for the glaciation which succeeded interglacial periods has been far more severe in the former region than in the latter. The remains of the Mammoth have, however, been found in Arctic America, in ice-cliffs at Kötzebue Sound, under conditions exactly similar to those of Siberia.

In Banks's Land, Prince Patrick's Island, and Melville Island, as in Northern Siberia, full-grown trees have been found in abundance at considerable distance in the interior, and at elevations of two or three hundred feet above sea level. The bark on many of them was in a perfect state. Captain McClure, Captain Osborn, and Lieutenant Mecham, by whom they were found, all agreed in thinking that they grew in the place where they were found.

It is true that more recent Arctic voyagers have come to the conclusion that these trees must have been drifted down the river from the south. There can be little doubt that the greater part of the wood found there, as in Siberia, is drift-wood. But may there not be, also, as in Siberia, two kinds of wood?—a "Noashina" and a "Adamshina," a kind which was drifted and another kind which grew on the spot. This is a point which will require to be determined.

That so little has as yet been done in the way of searching for such evidence of interglacial periods, is, doubtless, in a

* Phil. Mag. for July, 1874, p. 60.

great measure due to the fact that most of those, if not all, who have visited those regions entertained the belief that there is an *à priori* improbability that a condition of climate which would have allowed the growth of trees in such a place prevailed so recently as Post-tertiary times. Even supposing those Arctic voyagers had considered the finding of interglacial deposits a likely thing, and had in addition made special search for them, the simple fact that they should have failed to find any trace of them could not, as we have already shown, be regarded as even presumptive evidence that none existed. Take Scotland as an example. Abundant relics of interglacial age have there been found from time to time; but among the many geologists who visit that country year by year, how few of them have the good fortune of discovering a single relic. In fact, a geologist might search for months, and yet fail to meet with an interglacial deposit. The reason is obvious. The last ice-sheet, under which Scotland was buried, was so enormous as to remove every remnant of the preceding interglacial land-surface, except here and there in deep sheltered hollows, or in spots where it may happen to have been protected from the grinding power of the ice by projecting rocks. But all those places are now so completely covered with bowlder-clay and other deposits that it is only in the sinking of pits, quarries, in railway-cuttings, and other deep excavations that traces of them accidentally turn up. Now if it is so difficult to find in temperate regions, in a place like Scotland, interglacial remains, how much more difficult must it be to meet with them in Arctic regions where the destructive power of the ice must have been so much greater.

Something like indications of an interglacial period appear to have been found by Professor Nordenskjöld in Spitzbergen. "In the interior of Ice-fjord," he says, "and at several other places on the coast of Spitzbergen, one meets with indications either that the polar tracts were less completely covered with ice during the glacial era than is usually supposed, or that, in conformity with what has been observed in Switzerland, interglacial periods have also occurred in the polar regions. In some sandbeds not very much raised above the level of the sea one may, in fact, find the large shells of a mussel (*Mytilus edulis*) still living in the waters encircling the Scandinavian coast. It is now no longer found in the sea around Spitzbergen, having been probably routed out by the ice-masses constantly driven by the ocean-currents along the coasts."*

This testimony is the more valuable as it is given by an experienced geologist so much opposed to the theory of inter-

* "On former Climate of Polar regions," Geol. Mag., Nov. 1875, p. 531. See also "Geology of Spitzbergen," Geol. Mag., 1876, p. 267.

glacial periods. A more special and thorough search of those beds might probably reveal further indications of interglacial age.

Was Greenland free from Ice during any of the Interglacial Periods?—There is nothing whatever improbable in the supposition that during some of the earlier interglacial periods, when the eccentricity was about a maximum, the ice might have completely disappeared from Greenland, and the country become covered with vegetation.

Mr. Wallace thinks that the existence at present of an ice-sheet on Greenland is to be explained only by the fact that cold currents from the polar area flow down both sides of that continent. He further thinks that could these two Arctic currents be diverted from Greenland, "that country would become free from ice, and might even be completely forest-clad and habitable."*

I am inclined to agree with Mr. Wallace in thinking that the withdrawal of the two cold currents in question would effectually remove the ice. We know that Greenland is at present buried under ice, as has been shown on former occasions, simply because there happens to be about two inches more of ice annually formed than is actually melted. It certainly would not require any very great change in the present physical and climatic conditions of things to melt two additional inches per annum. If this were done the ice would ultimately disappear. A simple decrease in the volume of the two currents might possibly bring about such a result. A cause more effectual would, however, be an increase in the temperature and volume of the Arctic branch of the Gulf-stream.

NOTE.—This will probably be my last paper on questions relating to geological climate. There are many points I should have wished to consider more fully, but advancing years and declining health have rendered it necessary for me to abandon the subject altogether in order to be able to finish some work, in a wholly different field of inquiry, which has been laid aside for upwards of a quarter of a century.

* 'Island Life,' p. 149.

ART. XLII.—*Notes on some apparently undescribed forms of Fresh-water Infusoria. No.* 2;* by Dr. ALFRED C. STOKES. With Plate III.

THE subjoined fresh-water Infusoria which, so far as I am able to ascertain, have not been previously observed and are consequently undescribed, have, with a single exception, been obtained from the shallow ponds and streams of New Jersey. That they are restricted to that locality, however, is not probable.

Physomonas vestita, sp. nov.

Body subglobose, the anterior truncation obsolete; the entire surface clothed with a thin, mucilaginous, finely granular investment, through which penetrate numerous delicate, flexible, ray-like bodies apparently adherent to all points of the surface; endoplasm granular; long flagellum flexible, the distal extremity arcuately curved, twice the diameter of the body in length, the secondary one one-fourth that length, and vibratile; pedicle filiform, flexible, four times the diameter of the body in length; contractile vesicles two, situated close to and slightly in advance of the median line; a linear, slightly curved band or groove near the frontal margin of the body. Diameter of the zooid $\frac{1}{1666}$ inch. Habitat.—Pond-water, with Myriophyllum. Solitary.

In two particulars this species differs from the hitherto single known member of the genus:—in the absence of the truncated anterior border, and in presence of a linear, dark-bordered band or depression near the frontal margin, as exists in Spumella. In structure, habits and other essential characteristics it is a Physomonas. Influenced, however, by what I at first interpreted to be ray-like pseudopodia, I was not disposed to relegate it to any previously instituted genus, but felt compelled to form for its reception a new generic niche in the order Radio-Flagellata. Subsequent study, however, dispelled that idea and proved the animalcule to be an undescribed species of Physomonas. The radiating bodies project from all parts of the cuticular surface, and possess some of the characters of what Dr. Leidy, in his monograph on the fresh-water Rhizopoda, has styled "cils," being, in this instance permanent, non-vibratile, hair-like prolongations which need only to assume a rapid movement to become the familiar cilia. These spicular bodies have no circulation of their substance as do true pseudopodia emitted by the Rhizopoda and some of the lowest of the Infusoria; they are not retractile, neither do they take any part in the capture of food, as in members of the Radio-Flagellata where the nutritive particle,

* See this Journal, xxviii, 39, July, 1884.

dashed down by the short flagellum, is seized by one or more of the pseudopodic projections and drawn into the body. With this form the food, thrown down by the action of the short flagellum, enters at any part of the surface, usually near the base of the flagella, where the part opens, the mucilaginous investment and the adherent spicules moving outwardly on what appears to be a delicate cuticle, a wave-like outflow of the endoplasm surrounds the particle and draws it into the body enclosed in a large drop of water. In length these cuticular spicules are little shorter than the short flagellum.

The nucleus is indistinct and presumably centrally placed, although it was not positively identified. The two contractile vesicles pulsate alternately, and are distinctly apparent. The animalcule is shown in fig. 1, Plate III.

Bicoscœca lepteca, sp. nov.

Lorica sub-cylindrical, three times as large as broad, truncate and slightly narrowed anteriorly into an inconspicuous neck, somewhat inflated centrally, thence gradually tapering to the acute point of attachment to the pedicle whose length is equal to the greatest width of the lorica; animalcule ovate, with the usual oblique frontal border, the two diverse flagella and the eccentrically attached contractile ligament, the extended body projecting but a short distance beyond the lorica; pulsating vesicles two; nucleus sub-centrally placed. Length of lorica $\frac{1}{1500}$ to $\frac{1}{1800}$ inch; width $\frac{1}{4500}$; height of pedicle $\frac{1}{4600}$. Habitat.—Pond-water, with Myriophyllum and Algæ.

This minute creature is among the largest, if not the largest of the genus, the loricæ of the hitherto known species measuring from the $\frac{1}{3000}$ to the $\frac{1}{2500}$ inch in height, the one usually extending to the $\frac{1}{2500}$ inch is at times found to produce a sheath $\frac{1}{1600}$ inch high, thus in its most luxuriant growth only equalling the ordinary proportion of *Bicoscœca lepteca*, which consequently becomes the most gigantic of those yet recorded. From the only sweet-water species, *B. lacustris* J.-Clk., hitherto observed as a resident in American lakes, it differs so widely that to designate the points of dissimilarity would necessitate an extended description of the form here used in comparison. The loricæ, as is so common with those of the Vaginicolina, frequently change from the hyaline condition of youth to a semi-opaque chestnut-brown coloration of maturity and old age; and occasionally a deserted lorica is observed that, judging from this change of tint, is neither young nor mature, for the posterior half has assumed a translucent, chestnut hue while the remaining portion is as colorless as when first secreted. Arguing from this alteration, it is probable that the chemical composition of these sheaths is similar to those of the Vaginicolina,

and the pedicles of some of the Choano-Flagellata, in all of which the change has been observed.

The species is shown in fig. 2.

Bicosœca leptostoma, sp. nov.

Lorica elongate-ovate or subfusiform, three times as long as broad, tapering anteriorly to a short neck-like portion, the aperture very narrow, the margins not everted, the posterior half tapering to the pedicle whose length is equal to one-half the greatest width of the lorica; animalcule ovate or subpyriform, occupying the anterior half of the sheath, being entirely enclosed, with the exception of the long, lip-like projection extending beyond the aperture; contractile vesicles two, posteriorly placed; nucleus anteriorly situated. Length of lorica $\frac{1}{1500}$ inch; height of pedicle $\frac{1}{9000}$. Pond-water; attached to Myriophyllum and Algæ. Gregarious.

This form most closely resembles that of the salt-water *Bicosœca tenuis* S.-K., and may be considered its fresh-water representative; resembling it also in the proportion borne by the width of the lorica to the length, and in the short distance to which the extended animal protrudes itself, but differing in size, length of pedicle and in the form of the enclosed zooid. The narrow, lip-like prominence being the only portion of the body which extends beyond the lorica, it receives and accepts or rejects all food particles thrown upon it by the flagella. It is usually held arcuately curved, unwelcome particles commonly traversing its concavity to escape, as though urged by a strong current, acceptable matters being engulfed by an advancing wave of sarcode. The animalcule is shown in fig. 3.

Bicosœca longipes, sp. nov.

Lorica ovate, twice as long as wide, slightly narrowed anteriorly, the margin not everted, tapering towards its junction with the pedicle which is four or five times as long as the lorica; enclosed zooid subspherical, extending but a short distance beyond the aperture; contractile vesicles two, posteriorly situated. Length of lorica $\frac{1}{2250}$ inch. Habitat.—Pond water; attached to Myriophyllum. Solitary.

With this and the preceding species the long flagellum, when the retracted infusorian withdraws it into the lorica, is spirally coiled as is usual with all the members of the genus, but the great diameter of the coil is here horizontal, so that it appears to rest by its greatest width on the zooid's frontal border. Since my attention was especially called to this feature I have not obtained a specimen of the usually abundant *B. lacustris* J. Clk., but with it, I infer from Saville-Kent's remark, that the longest diameter of the coiled flagellum is vertical, so that the narrow

edge of the spring-like spiral rests on the anterior border of the zooid. Kent's figure exhibits it correctly as it occurs in the present species and the two preceding when about to uncoil itself, the spiral then assuming a vertical position, but he remarks that "the longer of the two flagella, as shown in fig. 17, is thrown into an elegant spiral coil, reminding the observer of the spirally retracted proboscis of a butterfly." This is assuredly not the case in the three species here described.* The lorica and extended animalcule of *B. longipes* are shown in fig. 4.

Stylobryon Abbotti, sp. nov.

Loricæ conical-campanulate, widest anteriorly, not everted, tapering without constriction to the pedicle, twice as long as broad, and united to each other by pedicles about one-half as long as a single lorica, into the cavity of which they are continued, becoming gradually attenuated to their extremity, each lorica usually bearing two loricæ which are apparently sessile on the antero-lateral borders of their supporting sheath; primary foot-stalk about six times as long as a single lorica; enclosed animalcule not conspicuously changeable in shape, ovate or subspherical, the projecting lip short; flagella two, the longer scarcely extending beyond the orifice of the lorica, to the posterior portion of which the infusorian is confined by a short, filamentous, contractile ligament; pulsating vesicle single, posteriorly placed; nucleus subcentral. Length of individual loricæ $\frac{1}{1500}$ inch; of primary pedicle $\frac{1}{250}$ inch. Habitat.—Pond water; attached to filamentous Algæ or other fine vegetable fibres.

This polythecium, unlike that of *Stylobryon petiolatum* (Duj.) S.-K., which it most resembles, is subject to but little variation in its mode of colony-building. As shown in fig. 5, from which most of the zooids have been intentionally omitted, its usual method is to erect a cluster of tapering, bell-shaped loricæ by attaching two to the frontal borders of the primary sheath and continuing in this manner until the polythecium is completed. Occasionally, however, the first or supporting lorica bears three, the third being centrally placed, but, so far as observed, not further continuing the tripartite arrangement. The number of loricæ composing the polythecium takes a considerable range with age. No colonies have as yet been noted with less than six, neither has it yet been my good fortune to

* Since writing the above I have seen Prof. Clark's original article in the "Memoirs of the Boston Society of Natural History," i, 1866, where, speaking of *B. gracillipes*, he says: "The only time that the flagellum abandons its rigid deportment is either when it is assisting the lip to seize the food, or during the spasmodic retrocession of the body. In the latter case it is abruptly retracted and coiled transversely within the calyx close down to the truncate front of the body." And of the flagellum of *B. lacustris* he says, "its flexibility is exhibited in the same way as in the other species."

obtain one of these beautiful polythecia exhibiting more than the thirty-one which composed the colony shown in the figure.

The loricæ, like those of *Bicosœca lepteca* referred to on a previous page, are remarkable for the great apparent facility with which they change their hyaline condition to a translucent but deep chestnut-brown coloration. As in the Bicosœca, again, this is occasionally accomplished so early that in some polythecia, although the terminal loricæ have seemed to be incomplete, yet their posterior portions have become brown while the remainder, apparently in process of formation, has been colorless and transparent.

In general appearance this form resembles *Stylobryon petiolatum*, differing, as has been stated, in being less variable in the manner of building up its polythecium, in the shape and posterior position of the enclosed zooids, in the more conical form of the individual loricæ, and especially in their much smaller size, those of *S. petiolatum* measuring from $\frac{1}{500}$ to $\frac{1}{800}$ inch, while with the present species none greater than $\frac{1}{1500}$ inch have been observed.

It gives me pleasure to dedicate the species to my friend Dr. Charles C. Abbott, the well-known archæologist and naturalist, near whose farm the beautiful colonies were originally obtained. It seems appropriate that the species should bear his name, since its habitat was the still waters of that attractive region, the vertebrate life of whose upland and meadow Dr. Abbott has described so charmingly in his "*Rambles of a Naturalist about Home*," and on whose fields and hillsides he has discovered so many evidences of paleolithic occupants, and so many specimens of their handiwork.

Tillina helia, sp. nov.

Body somewhat bean-shaped, or sub-elliptical with an anteriorly situated ventral concavity; twice as long as broad, slightly widest posteriorly, longitudinally striate and entirely ciliate, the cilia of the posterior extremity longest and most conspicuous, the anterior and posterior borders evenly rounded, the former somewhat curved toward the ventral aspect; oral aperture elongate-ovate, obliquely set within the anterior ventral concavity, followed by short, recurved, ciliated pharynx; contractile vesicle single, situated back of the body-centre in the right-hand lateral border, often leaving after systole a rosette of small vacuoles which finally coalesce; anal aperture opening on the ventral surface near the posterior extremity; nucleus large, ovate, subcentrally situated. Length of body $\frac{1}{300}$ inch. Habitat. Standing water, with Algæ.

Although the nucleus is correctly referred to as being subcentrally placed, its position in reference to any special region

is not constant. At times it is near and central to the dorsum, at others it is almost exactly in the center of the body, and occasionally it is found near the middle of the ventral surface. The majority of individuals examined had this important organ situated as shown in fig. 21, where it would seem to be in its normal position.

Derepyxis (*δερη, neck, πυξις, box*), gen. nov.

Animalcule single, inhabiting a pedicellate, flask-shaped lorica to which it is in no way attached; zooid subspherical, enclosing two laterally disposed color-bands; flagella two, subequal, rising from the center of the anterior margin; contractile vesicles two; pharynx presumably represented by a small, colorless space at the base of the flagella.

This is near Stein's Chrysopyxis, resembling it in the form of the enclosed zooid, its biflagellate condition and its entire freedom within the protecting sheath; but differing in the constantly pedicellate character of the lorica, the latter, in the genus instituted by the German authority, being sessilely attached to its support. The development of a conspicuous footstalk to the sheath of Derepyxis is sufficient to relegate its possessor to a new genus. The infusorian that habitually produces a pedicle before it secretes its lorica, is a little higher in the scale than one that develops a sessile lorica.

Derepyxis amphora, sp. nov.

Lorica flask-shaped, transparent, two and one-half to three times as long as wide, narrowed posteriorly and produced anteriorly in a cylindrical neck-like portion one-fifth the entire lorica in length, its circular border truncate, not everted; pedicle short, thick, about one-tenth the length of the lorica; enclosed animalcule occupying the center of the sheath, subspherical, somewhat compressed, the anterior border slightly pointed, this part usually colorless; the endoplasm with two, broad, lateral, greenish-yellow bands; flagella even, diverging, and projecting for a considerable distance beyond the lorica; nucleus not observed; contractile vesicles two, postero-terminal, pulsating alternately. Reproduction by longitudinal fission. Height of lorica $\frac{1}{900}$ inch; length of enclosed zooid $\frac{1}{1800}$ to $\frac{1}{2000}$. Habitat.—Pond water; attached to algal filaments.

This interesting creature occurs in considerable numbers on the finer filamentous fresh-water Algæ. The lateral color-bands are very broad, often appearing to surround the entire body, a high amplification in such instances being required to demonstrate the narrow chink of colorless endoplasm separating them longitudinally. The tint of these bands is a greenish-yellow deeping to a darker green at the periphery. The infu-

sorian is conspicuously gregarious in habit. It is shown in fig. 6.

Derepyxis ollula, sp. nov.

Lorica broadly flask-shaped, one and one-half times as long as broad, centrally subspherical, slightly narrowed at the posterior extremity, the neck-like portion subcylindrical, one-fourth as long as the entire lorica, the circular border not everted; pedicle short, stout, in length about one-eighth the entire height of the lorica; enclosed zooid spherical, the anterior border rounded; lateral color bands as in *D. amphora;* flagella of equal length; contractile vesicles posteriorly located, but not terminal. Height of lorica $\frac{1}{1125}$ inch; diameter of enclosed zooid $\frac{1}{2250}$. Reproduction by longitudinal fission. Habitat.—Pond water; attached to confervoid filaments. Solitary or few together.

This infusorian conspicuously differs from the preceding in the shape and size of the lorica, and in the more spherical contour of the enclosed zooid with its evenly convex frontal border. The tint of the color bands is about that of *D. amphora;* they are similarly broad, and also usually obscure the colorless central sarcode. The lorica and enclosed zooid are shown in fig. 7. It does not so abundantly ornament the supporting algal filament as does *D. amphora*, neither is it so frequently met with in the habitat preferred by both.

Chilomonas ovata, sp. nov.

Body evenly ovate, persistent in shape, once and one-half to twice as long as wide, rounded posteriorly, somewhat narrowed anteriorly, the frontal border obscurely bilabiate, the endoplasm enclosing numerous dark-bordered corpuscles; flagella subequal, exceeding the body in length, inserted close together at the anterior apex; contractile vesicles two, pulsating alternately, situated near the frontal margin; nucleus posteriorly placed. Length of body $\frac{1}{2250}$ to $\frac{1}{1800}$ inch. Habitat.—The bacterial pellicle on the surface of vegetable infusions.

This form was taken in abundance from the habitat mentioned, in company with a greater number of its comparatively gigantic relative, the *Chilomonas paramœcium* Ehr. It is readily distinguishable from the latter by its much smaller size, it indeed being the most minute fresh-water species yet recorded, by its long flagella, and particularly by the presence of two contractile vesicles, and the almost obsolete bilabiation of the frontal apex. The latter is so obscure, the border at times even appearing to be slightly pointed, and the contractile vesicle is so conspicuously double, that I have with some hesitation identified the infusorian as a member of the genus Chilo-

monas, but the other characteristics are so marked that it would seem preferable to slightly modify the generic diagnosis rather than to institute a new genus for its reception.

The dark-bordered corpuscles so numerous within this and *C. paramœcium*, are of an amylaceous nature, as is proved by their change to an intensely blue color when the animalcule is killed with iodine. The nucleus is usually so completely hidden by these superposed starchy corpuscles that it is positively located with difficulty. In several individuals, however, these bodies have chiefly collected in the anterior portion of the zooid, in which cases what I have taken to be the nucleus has been left in an almost subterminal position. The mature animalcule is shown in fig. 8.

Reproduction is accomplished by conjugation followed by encystment and quadruple subdivision. Union takes place by the adhesion of the two frontal borders, the body contents of one animalcule slowly passing into and mingling with those of the other, the latter gradually assuming a spherical form and exhibiting four actively moving flagella, as in fig. 9. That the zooids possess a distinct cuticular investment is proved during this process of protoplasmic transfer, for at that time, as shown in fig. 10, the posterior portion of the cuticular coat is left empty, the space slowly increasing in size until after the conjugation has been consummated; the completely vacated cuticular sac adheres to the quadriflagellate spherical result of the genetic union, as shown in fig. 9, whence it gradually melts away. The ultimate fate of the flagella I could not positively determine; my impression is, however, that they are absorbed. They remain visible and active for a considerable time after conjugation; in one instance a single flagellum did not entirely disappear until fission in one plane had been almost completed. The cuticular surface of the united animalcules, swollen into a sphere, becomes the cyst wall within which quadruple division takes place, the four young zooids thus formed differing from the mature infusorian apparently in size only.

In a single instance, previous to the union of the frontal borders, the four flagella became fused into two, after which I suppose the reproductive process proceeded as just described, but as I neglected to supply the water lost by evaporation from beneath the cover glass, the advancing wave swept them from the field and they were lost. Conjugation and encystment have not been observed in the other species of the genus, longitudinal fission prevailing generally.

Loxophyllum flexilis, sp. nov.

Body irregularly ovate, lanceolate or sub-triangular, three times as long as broad, transparent, lamellate, very soft and

flexible, widest posteriorly, tapering toward the anterior extremity which is somewhat curved toward the ventral aspect; the posterior margin obliquely and undulately rounded, the ventral border concave, the dorsal one irregularly convex, its posterior region bearing two small, conical elevations; the cuticular surface furrowed lengthwise, often thrown into longitudinal folds, entirely ciliated, the cilia of the anterior extremity somewhat longest and most conspicuous; oral aperture opening subterminally on the ventral surface; contractile vesicles three or more, the largest one postero-terminal, the others small and scattered; nucleus moniliform, the nodules irregularly ovate, centrally situated; trichocysts apparently wanting. Length of body $\frac{1}{200}$ inch. Habitat.—The bacterial pellicle on the surface of an infusion of dead leaves.

The movements of this infusorian are slow and even, with uncertain changes from one side to the other, and with equally unexpected contortions consisting of indescribable twistings and foldings of the body. The creature's remarkably irregular outline is made more so by the two little projections on the posterior part of the dorso-lateral border. These are constantly present, but vary somewhat in size and form. What utilitarian purpose they may subserve it is difficult to conjecture.

In a single instance I have observed what appeared to be genetic union of two of these animalcules. The combination resulting from this conjugation was almost indescribably irregular, being thrown into numerous folds and plications and rounded projections, the entire creature exhibiting the most deliberate and grotesque writhings and twistings. The separate animalcules were not seen previously to this apparent union, and so long as I was able to follow the apparent combination, no change except of form took place. The normal contour of the infusorian is shown in fig. 11.

Spirostomum loxodes, sp. nov.

Body elongate-fusiform, flattened, six to seven times as long as broad, widest centrally, tapering slightly toward both the anterior and posterior extremities, the former rounded and curved toward the left, with a short beak-like projection, the posterior margin truncate; cuticular surface obliquely striate, the cilia of the anterior and posterior borders more conspicuous than those of the general surface; peristome field occupying about one-third of the length of the body; nucleus moniliform, the nodules ovoid; contractile vesicle extending through the entire length of the right-hand border, with a conspicuous posterior dilatation; anal aperture postero-terminal. Length of body $\frac{1}{85}$ to $\frac{1}{75}$ inch. Habitat.—Pond water in Western New York.

In external contour this creature bears a striking resemblance to Loxodes, and might readily be mistaken for a member of that genus when casually examined with a low power of the microscope. In its own genus it approaches nearest to *Spirostomum teres* C. & L., which is without the acutely pointed sinistral curvature of the anterior margin, and differing also specifically in the presence of a moniliform instead of a single ovoid nucleus, and in the proportion borne by the width of the body to the length.

Reproduction takes place by transverse fission probably following conjugation, as individuals have been repeatedly obtained in the latter condition, the union, as observed, being effected by the mutual adhesion of the peristome fields throughout their entire length. The free-swimming infusorian is represented in fig. 12.

Vaginicola leptosoma, sp. nov.

Lorica subcylindrical, three and one-half to four times as long as broad, slightly inflated centrally, thence rapidly tapering to the narrow, truncated base of attachment, the lateral borders of the posterior portion often undulate, the circular anterior margin not everted; animalcule attached to the lorica by a short pedicle, the extended body narrowly elongate-conical, projecting for from one-third to one-half of its entire length beyond the lorica border, the cuticular surface finely striate transversely; nucleus elongate, band-like. Length of lorica $\frac{1}{150}$ inch. Habitat.—Pond water; attached to Algæ.

The lorica in form resembles that of *Vaginicola attenuata* (From.) S.-K., but is just twice as large, besides differing in the proportion borne by the length to the width. The contracted body of *V. attenuata* is described as urn-shaped; the present species when in that condition is simply obovate. The surface of the former is smooth. The cuticular striations of *V. leptosoma* are distinctly marked. This ornamentation of the surface has not been observed on any of the previously known species. The nucleus is remarkably elongate, extending through nearly the entire length of the body. The lorica and extended animalcule are shown in fig. 13.

Cothurnia annulata, sp. nov.

Lorica ovate, two and one-half times as long as broad, the posterior one-fourth widest and somewhat inflated yet tapering to the pedicle and often undulate, the posterior margin conspicuously thickened at the point of attachment to the foot-stalk, the anterior three-fourths, tapering to the circular, truncated margin, which is not everted; pedicle short, slightly narrower

than the extremity of the lorica, where it is apparently widened and continued through the thickened wall as a longitudinally striate prolongation or footstalk to the enclosed zooid; extended animalcule obconical, protruding but a short distance beyond the lorica, the cuticular surface transversely striate and bearing near its middle a narrow, transverse ring-like elevation or ridge. Length of lorica $\frac{1}{450}$ inch; greatest width $\frac{1}{1125}$; breadth of aperture, $\frac{1}{1500}$. Habitat.—Pond water; on Myriophyllum.

The enclosed animalcule here differs from all hitherto known species in the possession of a transversely striated cuticular surface, and the ridge-like elevation encircling the central portion of the body. These points alone are sufficient for diagnosis, although the lorica also differs in form from that of any previously described member of the genus. This with the extended animalcule are shown in fig. 14.

Litonotus vesiculosus, sp. nov.

Body elongate, sub-fusiform, produced posteriorly into a tapering, pointed, retractile tail-like prolongation equal to one-fourth the length of the entire body, and extended anteriorly into a narrow, flattened, flexible and extensile neck, about one-half the entire length of the body, its frontal border slightly dilated and widened and bearing trichocysts at the tip; dorsal region rounded, smooth, the ventral flattened, longitudinally furrowed and entirely ciliated; nuclei two, spherical, subcentrally located, and apparently without a funiculus; contractile vesicles numerous, small, scattered throughout the cortical layer of the body and extending in a series through the neck and tail-like prolongations; trichocysts scattered in the cortex of the center of the body; parenchyma of the entire animalcule slightly granular. Length of the extended body $\frac{1}{40}$ inch. Habitat.—Pond water; among Myriophyllum.

In form this resembles *Litonotus Wrzesniowskii* S.-K., but is undoubtedly distinct. The relative and proportionate length of tail and extensile neck to each other and to the central body, and the form of the caudal prolongation are very conspicuously different from that of the species dedicated to the Russian naturalist; and the trichocysts, instead of being arranged in a regular row at the border of the neck and obliquely directed, are scattered in no apparent order throughout the cortical layer of the central body and at the tip of the neck, but not elsewhere. This portion of the internal structure is of specific value. The chief diagnostic characters, however, in the internal structure, are the presence of very many minute, quickly and irregularly pulsating contractile vesicles scattered about the cortex, while in the animalcule most resem-

bling it the pulsating vacuole is large, single, and located near the origin of the caudal extremity. From *Litonotus pleurosigma*, described by the writer in the American Monthly Microscopical Journal for July, 1884, for which it might perhaps be mistaken if observed only in its contracted state, it differs in greater extensibility of the neck and tail, in the absence of the funiculus between the two nuclei, and especially in the arrangement of the contractile vesicles, those of *L. pleurosigma* being disposed in two rows, one on each side of the body near the ventral surface, while with *L. vesiculosus* they are not only more numerous, but are scattered throughout the body cortex as well as through the tail and neck.

Reproduction is by transverse fission, the dividing plane passing between the nuclei which have previously separated so that, as fission proceeds, each part of the animalcule has a single endoplast. Each nuclear nodule then elongates, quite rapidly divides transversely, the parts separating and becoming subspherical with some rapidity, so that before the completion of the reproductive act, each infusorial moiety possesses two disconnected nuclei, as did the parent. The mature infusorian is shown in fig. 15.

Litonotus carinatus, sp. nov.

Body elongate-lanceolate, five to six times as long as broad, extensile to a linear or subcylindrical form with vermicular movements, transparent and flexible, the tail-like prolongation short, obtuse, the neck-like portion in the mature zooid not distinctly distinguishable from the body, the anterior extremity slightly curved toward the right, not dilated; entire dorsal aspect traversed lengthwise by a narrow, convex, keel-like elevation; the ventral surface longitudinally striate, entirely ciliate; oral aperture subterminal; nucleus double, subcentrally placed, the nodules ovate and apparently connected without a funiculus; contractile vesicle single, near the posterior extremity; trichocysts few, confined to the left-hand border of the anterior body-half. Reproduction by transverse fission. Length of body $\frac{1}{300}$ to $\frac{1}{250}$ inch. Habitat.—The bacterial pellicle on the surface of an infusion of dead leaves.

The infusorian is represented in its dorsal aspect in fig. 16. It was obtained in great abundance on and beneath the jelly-like layer of bacterial and fungoid growths covering the surface of an infusion of various kinds of leaves, forming for some time the prevailing animalcule. It cannot be easily mistaken for any other species of the genus.

Litonotus trichocystus, sp. nov.

Body elongate-lanceolate, flexible and extensile, six to eight times as long as broad, widest centrally, slightly tapering toward the anterior extremity which is somewhat curved toward the right hand and depressed, but not conspicuously distinguishable from the body proper; tail-like prolongation short, posteriorly rounded; ventral surface longitudinally furrowed, entirely ciliate; endoplasm usually coarsely granular; nucleus double, the nodules subspherical, subcentrally placed and connected by a funiculus; contractile vesicle single, near the posterior extremity; trichocysts large, numerous, principally confined to the anterior body-half and the posterior extremity, in the former being arranged in an obliquely directed series along the left-hand border, a cluster at the frontal margin, a few on the right-hand border, many scattered irregularly through the cortex of the center of this region, and an irregular cluster at the extremity of the caudal prolongation. Length of body $\frac{1}{150}$ to $\frac{1}{200}$ inch. Reproduction by transverse fission. Habitat.—With the preceding in a vegetable infusion.

Examined in dorsal or ventral optical section this infusorian to a certain extent resembles *Litonotus fasciola* (Ehr.) S.-K. It is, however, easily distinguishable by its shorter and less conspicuously flattened neck-like part, and especially by the number and arrangement of the trichocysts, which are constant and will constitute the chief structural character, aside from contour, by which the animalcule may be readily identified. It is delineated in its extended state in fig. 17. When contracted it becomes broadly lanceolate.

Chilodon fluviatilis, sp. nov.

Body irregularly ovate, one and one-half times as long as broad, widest and rounded posteriorly, the left-hand lateral border truncate, the anterior lip-like projection rounded and obscure; ventral surface longitudinally furrowed, entirely ciliate, the cilia of the frontal border the most conspicuous; adoral groove obscure or absent; nucleus large, ovate, subcentrally situated; contractile vesicles numerous, scattered, a single, large, terminal vacuole often developed at the posterior extremity. Length of body $\frac{1}{100}$ inch. Habitat.—The water of the Delaware River at Trenton, N. J.

This differs from all other forms in its shape, the straight left-hand margin, which is thus far characteristic of it, in the absence of the lip-like prominence and the adoral groove, and in its preference for water not entirely still. The specimens were taken with Algæ from a rapid stream which forms the waste weir of the feeder to the Delaware and Raritan canal, the water

coming originally from the Delaware river, and at the point where the Chilodon was obtained returning to it once more, during its passage forming in the hollows of the rocks and among the little heaps of stones, small comparatively still pools where the oddly shaped creature was oftenest captured. It of course hardly lives and thrives in a foaming brook, nor stems the current of a miniature rapid, yet it seems to prefer a locality where the water is not placid as a mill-pond, although it will take kindly to quiet surroundings. I have preserved it in a vessel on my table for some weeks.

When under prolonged observation it frequently develops a large, postero-terminal vesicle in addition to the pulsating vacuoles constantly present, occupying the entire width of the terminal border and contracting at long intervals. The animalcule is shown in fig. 18.

Chilodon caudatus, sp. nov.

Body irregularly obovate, once and one-half to twice as long as broad, widest anteriorly, the frontal border and right-hand lateral margin rounded, the posterior extremity of the flat, entirely ciliated ventral surface tapering to an acute point, the symmetry of the left-hand lateral border interrupted by the sudden narrowing of the body, thus forming a conspicuous, acute, sinistrally projecting lip-like extension; the posterior extremity of the smooth, convex dorsal region produced in a short, conical, acuminate, free but motionless, spur-like prolongation; cilia of the frontal border longest and conspicuous; ciliated adoral groove distinct; oral aperture on the right hand side of the median line in the anterior body-half; contractile vesicles numerous, scattered; nucleus sub-spherical, coarsely granular, posteriorly located; anal aperture on the right-hand border near the posterior extremity. Length of body $\frac{1}{600}$ inch. Habitat.—Standing water, with *Azolla Caroliniana* Willd.

In other species a common characteristic of the dorsal region is to become suddenly elevated, and so merged into the general surface as to leave a comparatively flat margin or rim surrounding the lateral and posterior and often the frontal borders; but here, while this plane extension of the body exists laterally and at the rear, it is obscure or obsolete anteriorly, and the postero-terminal border of the dorsum is continued as an acuminate and rigid spur. This extension is not a mere narrowed portion adhering to the flattened region beneath, but a free and disconnected yet inflexible projection. That this has any other than an ornamental function I have not observed. It, with the prominent anterior lip, will render the infusorian readily recognizable. The dorsal aspect of the animalcule is shown in fig. 19, and a diagrammatic outline of the posterior portion in longitudinal section in fig. 20.

DEXIOTRICHA (*δεξιος, on the right-hand side, τριχιον, a little hair*), gen. nov.

Animalcules free-swimming, persistent in shape, entirely ciliate, elongate-ovate or subreniform, rounded posteriorly; oral aperture ventral, followed by a short, entirely ciliated, pharyngeal passage; one or more fine, hair-like setæ projecting from the posterior extremity of the body, and a single series of flexible, setose cilia extending transversely across the anterior right-hand ventral and lateral borders from the margin of the oral aperture to the margin of the dorsal surface; nucleus ovate; contractile vesicle single; anal aperture posteriorly situated.

In several structural points, in one attribute especially, the infusorian for which this new genus is instituted differs from all known animalcules. Its ordinal position is with the Heterotricha, and when a systematic treatise shall be written on our American infusoria, it will probably demand the formation of a new family group for its reception. It approaches nearest to the Bursariadæ of Stein, but diverges widely from the members of that family in the absence of the conspicuous, excavate peristome field, and especially in the presence of the row of adoral cilia on the right-hand side instead of the left, and in the presence of a ciliated pharynx, a feature to be distinguished only under high amplification and the most favorable position of the infusorian and the direction of the illuminating ray. Furthermore, the possession of a posteriorly projecting, filiform seta would alone force it out of that group.

Dexiotricha plagia, sp. nov.

Body elongate-ovate, two and one-half to three times as long as broad, the whole surface bearing minute, hemispherical protuberances which give the infusorian, in optical section, a crenulate outline; both extremities rounded, the posterior one widest, the frontal one slightly curved toward the ventral aspect, the anteriorly placed ventral concavity thus formed occupied by the ovate oral aperture; pharynx short, slightly recurved, its cilia projecting beyond the oral aperture; cilia setose; a single series of flexible, somewhat curved, setose cilia extending from the right-hand margin of the oral aperture obliquely backward and transversely across the right-hand side of the body to the border of the dorsal surface; a single, long, filiform seta projecting from the posterior extremity; nucleus ovate, subcentrally placed; contractile vesicle single, spherical, situated near the center of the ventral surface, at the right of the median line; endoplasm enclosing numerous small corpuscles, apparently bi-concave; anal aperture on the ventral surface

near the posterior extremity. Length $\frac{1}{430}$ to $\frac{1}{400}$ inch. Habitat.—An infusion of dead leaves. Reproduction by transverse fission.

The object of the unique, one-sided arrangement of the adoral cilia is to direct food particles to the mouth. When the animalcule is quietly feeding, the cilia of the general cuticular surface are all quiescent, with the exception of those on the right-hand side in advance of the adoral, lateral hedge of setose bristles. These alone being in motion, the currents which they produce carry the food particles against the stifly upheld cilia whose obliquely directed course turns the stream downward and forward to the oral aperture. The pharyngeal cilia project beyond the orifice in a comb-like fascicle only to be distinguished when the animalcule is resting and these appendages are motionless. The infusorian is shown in its right-hand lateral aspect by fig. 22, and the projecting pharyngeal cilia in fig. 23.

Trenton, N. J.

EXPLANATION OF FIGURES—PLATE III.

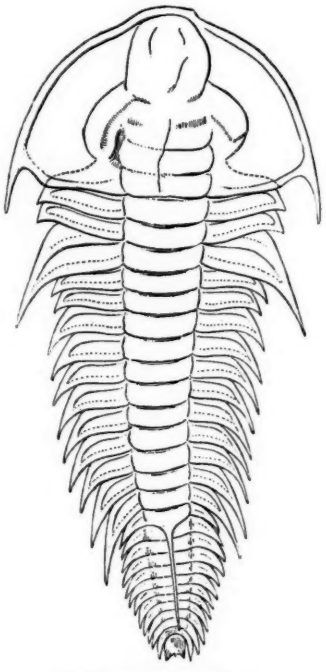
Fig. 1. *Physomonas vestita*, sp. nov. ×667.
Fig. 2. *Bicosœca lepteca*, sp. nov. ×1200
Fig. 3. *Bicosœca leptostoma*, sp. nov. ×1200.
Fig. 4. *Bicosœca longipes*, sp. nov. ×1200.
Fig. 5. *Stylobryon Abbotti*, sp. nov. ×600.
Fig. 6. *Derepyxis amphora*, gen. et. sp. nov. ×900.
Fig. 7. *Derepyxis ollula*, sp. nov. ×900.
Fig. 8. *Chilomonas ovata*, sp. nov. ×1575.
Fig. 9. *Ch. ovata* after conjugation with empty cuticular sac adhering.
Fig. 10. *Ch. ovata* in conjugation.
Fig. 11. *Loxophyllum flexilis*, sp. nov. ×260.
Fig. 12. *Spirostomum loxodes*, sp. nov. ×187.
Fig. 13. *Vaginicola leptosoma*, sp. nov. ×180.
Fig. 14. *Cothurnia anulata*, sp. nov. ×677.
Fig. 15. *Litonotus vesiculosus*, sp. nov. ×100.
Fig. 16. *Litonotus carinatus*, sp. nov. ×360.
Fig. 17. *Litonotus trichocystus*, sp. nov. ×350.
Fig. 18. *Chilodon fluviatilis*, sp. nov. ×400.
Fig. 19. *Chilodon caudatus*, sp. nov. ×720.
Fig. 20. *Ch. caudatus* in posterior, longitudinal optic section. Diagram.
Fig. 21. *Tillina helia*, sp. nov. ×270.
Fig. 22. *Dexiotricha plagia*, gen. et. sp. nov. ×530.
Fig. 23. *D. plagia*, showing ciliation of the pharynx.

ART. XLIII.—*Paleozoic Notes; New Genus of Cambrian Trilobites, Mesonacis;* by CHARLES D. WALCOTT, of the United States Geological Survey.

WHEN collecting fossils at Parker's quarry, in the town of Georgia, Vermont, in the season of 1883, we found a specimen of *Olenellus Vermontana* that appeared to have a body of

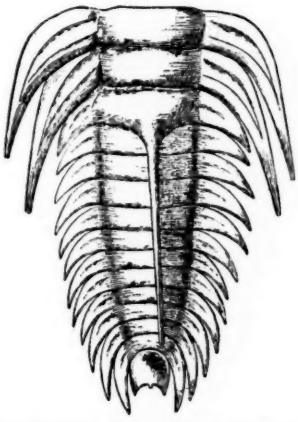
another trilobite attached to it, back of the fifteenth segment. In 1884 Mr. E. Hurlburt, of Utica, N. Y., was collecting in the same locality and found a more perfect specimen that showed the true structure of the trilobite. It was discovered to be the

Fig. 1.



Type specimen, nat. size.

Fig. 2.



Enlargement of the posterior portion of Fig. 1, showing the spine on the 15th segment and the posterior 10 segments and pygidium.

type of an undescribed genus that appears to be intermediate between the genera Paradoxides and Olenellus, or a form in which the characteristics of Paradoxides are changing into those of Olenellus, the head and first fourteen segments being, in all particulars, the type of Olenellus, and the pygidium and ten posterior segments more the type of Paradoxides; the fifteenth segment represents the telson of *Olenellus Thompsoni*.

The fifteenth segment fits snugly up against the fourteenth; the axial lobe is strong, and supports the base of a long, slender spine that, as now preserved, extends back to the pygidium; the base of the spine originates on the dorsal surface of the segment and also extends back so as to include the posterior margin, and causes the latter to curve back towards the center; the lateral pleuræ of the segment are short and, in structure, diminutive representatives of the large pleuræ of the segments anterior to the fifteenth.

The succeeding eleven posterior segments appear as though formed of a more delicate test than the anterior portions of the body, as they are much more flattened and compressed than the latter, and the plural grooves are almost obsolete. The pygidium is also small and delicate.

The body, back of the spine-bearing segment, appears as though belonging to a different animal, and looks more like that of a Remopleurides than either Olenellus or Paradoxides, but on a close examination, the pygidium is found to be much like that of *Paradoxides rugulosus*, and the free pleuræ bend back as in that species.

For this form the genus *Mesonacis* is proposed. One other species, *O. Howelli*, from Central Nevada, will probably be referred to it when the thorax and pygidium are found, as the head is very closely related to that of *M. Vermontana*.

The stratigraphic position of *M. Vermontana* is eleven hundred feet from the base of the Georgian Group, in the argillaceous shales at Parker's quarry, town of Georgia, Franklin county, Vermont, where it is associated with *Olenellus Thompsoni*, *Protocaris Marshi*, *Ptychoparia Adamsi*, etc.

The Georgian Group, in Vermont, consists of one thousand feet of magnesian limestone at the base, overlaid by from eight thousand to nine thousand feet of argillaceous shales in which great lenticular masses of limestone occur that carry a fauna similar to that of the shales. The base of the group and also its summit is at present unknown.

In Central Nevada, in an unbroken section, the Potsdam fauna, as found in New York and Wisconsin, occurs four thousand feet above the characteristic Georgian fauna, the intervening strata being entirely formed of limestones.

In a paper now in course of preparation by the writer, sections will be given, accompanied by lists of fossils, to show the relations of the St. John (Paradoxides), Georgian (Olenellus) and Potsdam (Dicellocephalus) Groups, or the Lower, Middle and Upper Cambrian.

In Bulletin 10, of the U. S. Geological Survey, the subgenus Salteria is proposed by the writer to include *Conocoryphe Baileyi*, Hartt and *C. venulosa* Salter of the Lower Cambrian. The name had been previously given to a genus of trilobites (Mem. Geol. Surv. Brit. Organic Remains, Dec. xi, pl. vi) which necessitates the substitution of another subgeneric name for the species mentioned. Mr. G. F. Matthew (Trans. Roy. Soc. Canada, vol. xi, description of pl. i) having proposed the name *Bailiella*, that will replace Sateria as applied to *Conocoryphe* (*Bailliella*) *Baileyi* of the St. John Group.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Specific Heat of the Elements at High Temperatures.*—In the course of their researches on the heat-relations of the explosion of gaseous mixtures, Berthelot and Vieille have been able to obtain the specific heat of the elementary gases at high temperatures. The experimental data were obtained by the combustion of cyanogen mixed with sufficient oxygen to convert it into carbon monoxide and nitrogen; two gases which have sensibly the same specific heat. From the pressure developed in the explosion, the temperature referred to the air thermometer was calculated; and from the total quantity of heat produced and the temperature, the specific heat (at constant volume) of the resulting gaseous mixture was derived, and hence the specific heat of either of the resulting gases. The results of six experiments of this sort were as follows:

	Pressure	*Heat*		*Specific heat*	
Mixtures.	*developed, atm.*	*evolved.*	*Temperature.*	*Total. For* N_2 *and* CO.	
$C_2N_2+O_2$	25.11	126500 cal.	4394°	28·81	9·60
$C_2N_2+O_2+1\frac{1}{2}N_2$	20·67	126500	4024	31·46	8·39
$C_2N_2+O_2+2N_2$	15·26	126500	3191	39·67	7·93
$C_2N_2+O_2+\frac{7}{2}\frac{3}{1}N_2$	11·78	126500	2810	45·05	6 67
C_2N_2+2NO	23·34	169800	4309	39·39	9·85
$C_2N_2+2N_2O$	26·02	168400	3993	42·17	8·43

It will be noticed that the numbers obtained are closely identical whether oxygen, nitrogen monoxide or dioxide is used to effect the combustion; thus at 4400° the specific heat with oxygen is 9·60 and with nitrogen dioxide 9·85, the ratio of N to CO being 1 : 1 by volume. At 4000°, with oxygen, the specific heat was found to be 8·39, and with nitrogen monoxide 8·43, the ratio of N to CO being 3 : 2 by volume. Moreover it will be observed that the specific heat increases rapidly with the temperature. This increase may be expressed as a function of the temperature by the empirical formula

$$C=6{\cdot}7+0{\cdot}0016(t-2800)$$

giving the following calculated value: at 2800°, 6·7; 3200°, 7·3; 4000°, 8·6; and 4400°, 9·3; the observed numbers being 6·7, 7·9, 8·4 and 9·6 respectively. These numbers may be adopted as expressing, at high temperatures and constant volume, the molecular specific heat of the simple gases, N_2, H_2 and O_2 as well as of the compund gas CO which is closely related to them. It is therefore evident that in passing from 0° to 4500° the mean specific heat of the elementary and simple gases nearly doubles. There is, however, another group of elementary and of compound

gases to be considered. Regnault showed that the specific heat of chlorine, bromine and iodine were higher than that of the other elements, being 6·6 at constant volume instead of 4·8. The remarkable fact is that this specific heat is closely the same as that of the compound gases which are formed with a contraction of one-third in volume, as water, nitrogen monoxide and carbon dioxide. The data were obtained by combining chlorine and hydrogen in presence of an excess of one or the other of these gases; from which it appeared that the weight $\frac{2}{3}$ Cl was sensibly equal to that of H_2. The mean specific heat of chlorine at constant volume was found to be at 1800° nearly three times that of hydrogen; the latter being 5·1 and the former 15·3 nearly. Chlorine comports itself toward oxygen as ozone would do if it were stable and were formed with the evolution of heat.—*Ann. Chem. Phys.*, VI, iv, 66, Jan. 1885. G. F. B.

2. *On the Specific Heat of Water and of Carbon dioxide at High Temperatures.*—In a second paper, BERTHELOT and VIEILLE have given the results of similar calculations to determine the mean molecular specific heat of water and of carbon dioxide. The hydrogen was burned with oxygen either alone or mixed with nitrogen; in the latter case the specific heat of the nitrogen was subtracted. The following table gives the data and the calculated values obtained:

Mixture.	*T.*	*Total specific heat.*	*Sp. Heat of the N.*	*Mean mol. spec. heat of* H_2O *between* 0° *and* T°.
H_2+O	3240°	18·12		18.12
$H_2+O+\frac{1}{2}N$	2860	20·52	1·69	18·83
H_2+O+N_2	2543	23·08	6·26	16·82
H_2+O+2N_2	2180	26·93	11·36	15·57
H_2+O+3N_2	1798	32·05	15·21	16.84
H_2+N_2O	3133	25·09	7·20	17·89
$H_2+N_2O+N_2$	2601	30·60	12·70	17.90

The value given in the fifth experiment is not regarded as reliable as the others, since the large amount of inert gas present caused the combustion to be twelve times as slow. It will be observed that here also the specific heat increases with the temperature. The authors represent this increase by the empirical formula:

$$C=16·2+0·0019(T-2000)$$

Since the mean specific heat of water vapor between 130° and 230° is 6·65 at constant volume, it appears that it is more than doubled at 2000° and tripled at 4000°. On comparing the elementary specific heat of the vapor of water with that of its constituent elements, it appears that the former value is in excess of the latter at 2000° by 7·0 and at 4000° by 5·1. This excess represents a double work, first that of the molecular disaggregation of the compound gas, and second that of its chemical dissociation. The values obtained for carbon dioxide are given as follows:

Mixture.	*T.*	*Total specific heat.*	*Specific heat of the N.*	*Specific heat of the* CO_2.
$CO+O$	3334°	20·40		20·40
$CO+O+N$	2840	24·02	3·36	20·66
$CO+O+N_2$	2548	26·69	6·27	20·42
$CO+O+N_5$	1807	37·47	12·67	24·80
$C_2N_2+O_4$	4862	54·00	10·00	22·00
$C_2N_2+O_4+N_2$	4082	64·31	17·50	23·40
$C_2N_2+4N_2O$	3972	86.71	42·70	22·00

The fourth of these results is inaccurate owing to the extreme slowness of the combustion. The results with CO give a mean value of 20·5 between 0° and 2900°; those with CN give 22·5 between 0° and 4300°. Taking them together they may be represented by the empirical formula:

$$C=19·1+0·0015(T-2000)$$

This gives for the elementary specific heat of carbon dioxide at 2000°, 19·1; at 3000°, 22·1 and at 4000°, 25·1. The mean specific heat of this gas, therefore, more than triples, and the elementary specific heat quadruples, between 0° and 4300°.—*Am. Chim. Phys.*, VI, iv, 74, Jan., 1885. G. F. B.

3. *On the Action of Hydrogen peroxide on the Hydrates of the rarer earths.*—Clève has studied the production of peroxides of the rarer earth-metals by the action of hydrogen peroxide upon their hydrates. Gelatinous precipitates were obtained which were washed by decantation, care being taken to avoid elevation of temperature, and in some cases dried over sulphuric acid. The oxygen was determined by dissolving the moist precipitate in dilute sulphuric acid and titrating the hydrogen peroxide thus formed with permanganate. In the dry precipitates the oxygen was determined by dissolving them in dilute sulphuric acid containing ammoniacal ferrous sulphate, and titering back with permanganate. Hydrogen peroxide gave the same result with both these methods; but cerium peroxide gave only half as much oxygen by the first method as by the second. The oxides of yttrium, lanthanum, samarium and didymium, whose formula is R_2O_3, act in the same manner with H_2O_2 and give peroxides of the formula R_4O_9, approaching R_2O_5. The oxides of zirconium and cerium, RO_2, give like titanic acid peroxides of the formula RO_3. The oxide of thorium, which belongs to the same group gives the peroxide R_2O_7.—*Bull. Soc. Chim.*, II, xliii, 53, Jan., 1885.

G. F. B.

4. *On the Determination of small quantities of Hydrogen sulphide in Gaseous mixtures.*—For the purpose of determining the quantity of hydrogen sulphide contained in mixtures of gases, Osmond passes the gas to be tested through a series of bulbs containing a known quantity of titred solution of silver nitrate. As soon as the silver in the first bulb is entirely precipitated as sulphide, the precipitation begins in the second. If the quantity and strength of the silver solution in each bulb corresponds to a definite quantity of sulphur, say 0·01 per cent, then it is only

necessary at the end of the experiment to count the bulbs containing sulphide and the quantity of sulphur in the gas passed through the apparatus is at once known. Obviously the limit of accuracy in the method may be varied at will by varying the strength of the solution and the number of bulbs. If the test is to determine only whether the amount of sulphur is inferior to a certain maximum limit or not, two bulbs suffice. In the first the quantity of the reagent corresponding to this maximum is placed, if any blackening appears in the second, then there is an excess of sulphur over the permissible amount.—*Bull. Soc. Chim.*, II, xliii, 70, Jan., 1885. G. F. B.

5. *On the Atomic weight of Titanium.*—THORPE has made a series of elaborate and careful determinations of the atomic weight of titanium, using several methods. The product employed was, in the former set of experiments, titanium tetrachloride and in the latter titanium tetrabromide. In the first method a known quantity of the tetrachloride was placed in water, a quantity of silver slightly less than was required to completely precipitate it was dissolved in nitric acid and added to it, and then the remaining excess of chlorine estimated by means of a graduated solution. Eight experiments gave 48·06, 48·07, 47·98, 48·04, 48·04, 48·06, 47·94, 47·93. In the second method the precipitated silver was collected and weighed, and gave 47·99, 47·97, 48·00, 48·05, 48·05. The third method consisted in decomposing a known quantity of the tetrachloride with water, evaporating the product to dryness in a platinum dish and weighing the resulting titanic oxide. Six experiments gave 47·93, 48·00, 47·99, 47·96, 47·98, 47·94. In the second set of experiments, tetrabromide was used. When decomposed with water and titered with silver, the numbers obtained were 48·04, 48·06, 48·02, 48·03, 48·04. The weighed AgCl gave 47·95, 47·99, 48·19, 48·02. Conversion into titanic oxide gave 48·08, 47·97, 47·94. The number 48 which corresponds to Mendelejeff's table is the most probable atomic weight.—*J. Chem. Soc.*, xlvii, 108, Feb., 1885.

G. F. B.

6. *On Raffinose from Molasses.*—TOLLENS has examined a sample of sugar which crystallized out of a molasses prepared in a sugar house by precipitation with strontium hydrate. The crystals were separated by washing with alcohol from the adhering syrup, and purified by recrystallization. On analysis they afforded the formula $C_{12}H_{22}O_{11}+(H_2O)_3$. When the normal solution was examined in the polariscope, it gave a specific rotation $(\alpha)_D=102{\cdot}5$ —103°. When heated with sulphuric acid, the rotation fell to 45°. Fehling's solution is unaffected by it; but this solution is strongly reduced by it after the action of acids. It resembles the raffinose of Loiseau and the melitose of Berthelot.—*Ber. Berl. Chem. Ges.*, xviii, 26, Jan., 1885. G. F. B.

7. *Influence of an Electric Current in modifying the rate of thinning of a liquid film.*—Professors REINOLD and RÜCKER have discovered that an electric current passing through thin soap-

bubble films modifies in an interesting manner the rate of thinning of the films. The liquid employed was either a solution of potash soap in water or Plateau's *liquide glycérique* containing a certain proportion of niter to increase its conductivity. The films had the form of vertical cylinders—the upper and lower supports being of platinum. The films were blown with air which was first dried and then passed over some of the soap solution in a wide tube so that the condition of the air inside the tube was approximately that of the air on the outside. The electric current varied from about 100 microampères to half a microampère. The downward current was found to increase the rate of thinning of the film and the upward current to retard it.—*Phil. Mag.*, Feb. 1885, pp. 94–100. J. T.

8. *On the Conduction of Electricity in rarefied air.*—It has been maintained by EDLUND in various papers that what is called a vacuum conducts electricity and that this conductivity increases with the degree of rarefaction. In the present paper he reiterates his reasons for believing that a discharge between platinum terminals in a Geissler tube could be obtained at a certain point of the exhaustion, if the effect of the electrodes in opposing the passage of the electricity into the gas could be overcome. He brings forward as evidence certain experiments in which a discharge is obtained through the glass sides of tubes containing rarefied air, through which no discharge could be obtained if platinum electrodes were used. *Phil. Mag.*, Feb. 1885, pp. 125–131. J. T.

9. *Measurement of Rotation of plane of polarization of liquids in a magnetic field.*—It has been suggested by various observers that the rotation of the plane of polarization of certain liquids placed in a magnetic field could be used as a measure of very strong currents. LEO ARONS has redetermined Verdet's constant for this purpose, and believes that his result for distilled water at 23° C. and the wave-length of the sodium line, namely,

$$w = 0{\cdot}3767.10^{-5} \text{ cm}^{-\frac{1}{2}} \text{ g}^{-\frac{1}{2}} \text{ sec}$$

is within 0·5 per cent.—*Ann. der Physik und Chemie*, No. 2, 1885, pp. 161–182. J. T.

10. *On some Physical Properties of Ice.*—MR. COUTTS TROTTER, fellow of Trinity College, Cambridge, has instituted some experiments on ice in an artificial grotto in a glacier near Grindelwald, in order to see, "if evidence of shearing under the influence of forces comparable to those which Canon Moseley admits to be capable of being produced by the action of gravity in a moving glacier could be obtained." Bars of ice were passed through holes in three parallel blocks of wood, nearly in contact with each other. The two outer blocks were hung to a frame, and a weight was suspended from the middle one. After the ice had hung for a few days, the apparatus was taken to pieces and the shear measured. In a final experiment a shear of about ·075 cm. was observed after the action for about seventeen days of a shearing force of rather more

than 200 grm. per square centimeter. Mr. Trotter is led to support the conclusions of Forbes, that glacier motion is that of a slightly viscous mass partly sliding upon its bed, partly shearing upon itself under the influence of gravity. Regelation also plays a part in the gradual passage of snow into ice and in the healing of crevasses.—*Royal Soc.*, Jan. 29; *Nature*, Feb. 5, 1885, p. 328.

J. T.

11. *Photographing the Solar Corona.*—Mr. C. RAY WOODS, who was sent to Switzerland to photograph the solar corona according to the method devised by Dr. Huggins, sums up in the *Observatory* the results thus far obtained, as follows:

(1) As would be expected, the results are better than had been obtained in England, in spite of the red haze which has been always present round the sun, and which visitors to Switzerland have commented on in several of the scientific journals recently.

(2) Results on the same day are almost, if not quite alike, both *with* disk and *without.*

(3) The corona varies more or less from day to day.

(4) The clearer the sky the better the results.

(5) The series extends over a period of two months, a one month's results being free from effects that require elimination.

12. *Magneto- and Dynamo-Electric Machines*, with a description of Electric Accumulators, from the German of Glaser-DeCew; by F. KROHN, and specially edited with many additions by PAGET HIGGS, LL.D., etc. 301 pp. 8vo. London (Symons & Co.—The Specialists' Series, vol. i). This work is essentially a reproduction of the excellent little volume which formed No. 1 of the Elektro-technische Bibliothek, published in Vienna some two years since and at that time noticed in this Journal. The English editor has increased the value and scope of the volume by adding a number of chapters relating to the details in the construction and use of the machines. The subject at hand is too vast in its present development to allow of being treated thoroughly in a book of this size, but the reader will find in this volume a good selection of matter and will profit from its perusal.

II. GEOLOGY AND MINERALOGY.

1. *Professor W. O. Crosby on the origin and relations of continents and ocean basins*, (Proc. Bost. Soc. Nat. Hist. for Nov., 1883; but recently printed.)—In this paper Professor Crosby discusses the contraction theory for the origin of continents and oceanic basins with some good arguments against the theory and others not so good, and arrives at the conclusion that the continental and oceanic areas have not always been essentially the same in limits as now, with relatively moderate submergences over the former and emergences over the latter, but that an Atlantic continent continued in existence through Paleozoic times, providing Paleozoic sediments for North America, and producing, in its sinking, pressure against the continent, which resulted in causing Appalachian foldings and uplift.

The writer's views are discussed in the paper though sometimes put in a form that is hardly recognizable. Professor Crosby, on the page before the last, says that Professor Dana, believing that the Atlantic existed with nearly its present outlines during Paleozoic time, and that the foldings of the Appalachian rocks were made by subsidence over the Atlantic area, thus "admits that the Appalachian sediments were separated from the Atlantic by at least one hundred and possibly several hundred miles of dry land;" "in other words, Professor Dana tells us that the sediments deposited in one ocean were plicated by the subsidence of the floor of another and entirely distinct ocean."

In reply to this remark I observe that the Appalachian area of subsidence through Paleozoic time—which ranged parallel with ridges of Archæan rocks and with the Atlantic border, was not "one ocean;" it was generally (according to evidence from the strata) a shallow part of the continental border, receiving its depositions in shallow waters. The Appalachian trough, or geosynclinal was, it is true, distant a hundred miles or more from the ocean's border; but I have suggested that it was probably separated by a low geanticlinal—emerged or slightly submerged; that the general contraction in the earth's crust, and especially of that part beneath the oceanic area, produced along the ocean's border, the geanticlinal as well as the geosynclinal, the two being concomitants in a system of flexures. I do not, therefore, see the appositeness of Professor Crosby's comparison which he adds in closing his paragraph: "This is very much the same as saying that the sediments now accumulating in the Gulf of Mexico will some day be compressed and folded by the subsidence of the bottom of the Pacific, Central America and Mexico remaining undisturbed as at present."

It is unnecessary to touch on other points of disagreement in the memoir. Moreover, I am led by the conflicting views of the best authorities with regard to the condition of the earth's interior to hold very loosely to any theory of mountain making. We wait for the physicists who believe in a solid earth to give us a theory which will have in view all geological facts. At present we get from them little more than an acknowledgment that no theory is yet in sight, or a disposal of the subject by passing it over to the "geologist," instead of recognizing that the facts, although geological, are physical and merit attention from physicists as much as the tides and more purely mathematical considerations.

The idea that the continents and ocean-basins have been in continued progress as such through the geological ages I regard as established upon as good evidence nearly as the fact that an animal is a result of slow development from a germ; and this evidence is similar in general nature, it consisting in direct knowledge of the successive conditions or steps of progress in the development. The facts from America are, as I have shown, the facts that make up the historical geology of the continent.

The Archæan dry lands are now believed to have had a wide distribution over eastern, northern and western America, as I point out in the more recent edition of my Manual (even New England having Archæan areas in both its eastern and western portions), and the regions within reach of abrading and degrading agencies were therefore of sufficient extent for the needed Paleozoic sediment-making. The sediments can, in many cases, be proved to have come from regions not far distant; the succession of mud-made rocks and those of beach or sand-flat origin, to have the relative positions of the beaches, sand flats and offshore deposits of a growing continent; and one example of this I shall present in the following number of this Journal. Moreover, facts with regard to marine currents and wave-action, oceanic and sea-shore depositions, show that another continent in the Atlantic could have given no help had it existed. J. D. D.

2. *The Geology of Bermuda.*—Professor Wm. N. Rice, of Middletown, Ct., has a valuable paper on this subject in Bulletin No. 25, U. S. National Museum, Washington, bearing date 1884, but issued the present year. It is accompanied by a map and other illustrations. Professor Rice after a special examination of the coral formations of the island agrees with Wyville Thomson in the conclusion that none of the rock above a level of fifteen feet is true under-water coral reef rock; it is either of beach or wind-drift origin, although in some parts 250 feet in height. Three changes of level appear to have occurred; that in which the original island subsided and the atoll was made; the second an uplift above the present level; the third a subsidence which led to extensive marine erosion of the wind-drift rock and the formation of the shore platform and cliffs. The supposed evidence of recent sinking is reviewed and the conclusion reached that none has taken place at least since 1609—the time of the shipwreck of Sir Thomas Gates and Sir George Somers. Darwin's theory of the origin of atolls appears to be sustained by the fact that at a distance of ten miles from the Bermudas in all directions, excepting the southwest, the depth is from 1500 to 2250 fathoms.

3. *C. D. Walcott on the Deer Creek Coal-field in Arizona.* (Senate Doc., No. 20, 48th Congress, 2d Session).—Deer Creek valley is about 13 miles south of the San Carlos agency, between two spurs of the foot-hills sloping down from Mount Trumbull to the Gila. Mr. Walcott states that in a section across the upper end of the coal field there is rhyolyte to the north and andesyte to the south. The northern boundary of the valley consists of a belt of Carboniferous limestone 1200 feet thick; south of this occur Cretaceous sandstone, clays and coal seams, nearly 3700 feet in thickness, apparently conformable to the underlying Carboniferous. There is also a band of Devonian limestone. The rhyolyte and andesite outflows were subsequent to the erosion of the valley.

The coal beds are in sandstone referred to the Cretaceous; two

beds have each a thickness of about ten inches clear coal. The coal is bituminous, one analysis by Mr. Whitfield obtaining fixed carbon 60·85, volatile combustible matters 17·50, moisture 0·56, ash 21·09=100.

The fossils of the Carboniferous limestone determined by Mr. Walcott include *Fusulina cylindrica*, *Productus semireticulatus*, *Spirifera camerata* and other species. The coal shales, according to Mr. Lester O. Ward, contain remains of *Sequoia*, *Sabal*, *Phragmites*, *Myrica*, *Viburnum*, and other kinds.

4. *Crinoids with Articulating Spines.*—Dr. G. J. Hinde, in the Annals and Magazine of Natural History for March, describes and figures fine specimens of a Crinoid from Arkona, Province Ontario, Canada, having articulating spines. He refers to a paper by Professor H. S. Williams in the Proceedings of the American Philosophical Society for 1883, on a species of the kind—the first discovered—which this author referred to the new genus *Arthroacantha*. As this name essentially had been used in 1854 by Schmarda for a genus of Rotatoria, Dr. Hinde substitutes *Hystricrinus*, and names his species *H. Carpenteri*, after Dr. P. Herbert Carpenter.

The remarkable fact is mentioned (and figured) that three of the eleven specimens obtained have a shell of the genus *Platyceras* Conrad, covering almost entirely the vault of the Crinoid, and with the same position in all; in one the shell is *P. erectum* Hall, in the others, a small variety of *P. dumosum* Conrad.

5. *Creation of Continents by the Ocean Currents;* by J. Stanley Grimes. 116 pp. 12mo. Philadelphia, 1885 (J. B. Lippincott & Co.).—The author aims to show that the three pairs of ocean-basins—those of the North and South Atlantic, Pacific and Indian ocean—were produced through the weight of the sediment collected over the ocean's floor by three pairs of elliptical currents; that the sinking of the basins drove under the interoceanic crust the fluid or plastic rock beneath, and so made the three pairs of continents; that the elliptical oceanic currents flowed about an east and west major axis between the equator and the 45th parallel, and that the southern ellipses were about 50° in longitude east of the northern.

6. *Note on the Sandstones of Taquamenon Bay, Lake Superior;* by N. H. Winchell.—The editorial note of this Journal, to which Professor Irving takes exception in the March number, page 258, was so worded in its relation to the subject under consideration as to allow an erroneous inference as to the opinion of the writer respecting the age of the sandstones of Taquamenon Bay. This inference having been taken by Professor Irving he has taken considerable trouble to show that I am wrong in holding such a (presumed) opinion. Professor Dana quotes correctly from my tenth annual report (page 133), and if Professor Irving had consulted the same page he could have seen that the italic "*if*" which introduces Professor Dana's quotation throws almost the force of a negative against the inference which he assumes as

legitimate; and that really the argument of the whole paragraph from which the quotation is made is intended to show such a negative. The word "conspicuous" in that paragraph is a misprint for calciferous, as noted in the errata.

Minneapolis, March 4, 1885.

7. *Grand Atlas of the Second Geological Survey of Pennsylvania;* J. P. LESLEY, State Geologist, Division I. County Geological Maps, Part I. 50 sheets imperial folio. Harrisburg, 1885.—A grand atlas in fact is this first part of the atlas of the Pennsylvania Survey. The best style of map-making and map-coloring have been employed in illustration of the results of excellent detailed geological work. This Part I contains maps of fifty-six counties on forty-nine sheets. As this Journal has many times stated, the survey has gone forward with remarkable energy and thoroughness under its efficient and experienced head; and, owing to the varied resources of the State, has become more valuable as regards its economical results than that of any other State in the Union. It has also contributed largely to paleontology especially through its volumes on coal plants, and thrown light on many of the problems in American stratigraphical and dynamical geology. The anthracite survey is making good progress, and also the unfinished geological surveys of a few of the counties. The final report is in course of preparation by Professor Lesley and, when finished, will make the survey of largely increased value to the State through the systematic presentation of the facts and results now distributed with great detail in the several county reports. Pennsylvania surpasses all other States in its mineral wealth, and can therefore well afford to have prepared and published the most extensive of all geological and mineral State reports.

8. *Map of the Dominion of Canada geologically colored from surveys made by the geological corps,* 1842 to 1882. Geological and Natural History Survey of Canada, A. R. C. SELWYN, Director.—This fine map measures six feet across, and is a valuable contribution to American geological science. The survey has accomplished a great work in gathering the materials for so detailed a map.

9. *New Minerals from Colorado:* ZUNYITE, GUITERMANITE.—Dr. W. F. HILLEBRAND has recently described two new minerals from the Zuñi mine on Anvil Mountain, near Silverton, San Juan Co., Colorado. Zunyite occurs in very minute tetrahedral crystals showing the faces of both the plus and minus tetrahedrons, parallel to which there is easy cleavage, and frequently also those of the cube and perhaps the dodecahedron. The crystals are transparent, except for frequent black inclusions of titanic oxide, and have a glassy luster; the hardness is 7 and the specific gravity of the pure mineral 2·875. The mean of a number of partial analyses made upon material selected with all possible care is

SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	Li_2O	H_2O	P_2O_5	F	Cl
24·33	0·20	57·88	0·10	0·24	tr.	10·89	0·60	5·61	2·91=102·76

less O for F and Cl 3·02=99·74

In calculating the formula the Fe_2O_3 and P_2O_5 are neglected as due to impurity, and the water is assumed to be basic since it does not go off at 270° C. The atomic ratio for Si : (Al_2) : (H, K, Na) : (O, F_2, Cl_2) = 0·4055 : 0·5674 : 1·2208 : 3·1232 or nearly 6 : 8 : 18 : 45, corresponding to $9R_2O, 8Al_2O_3, 6SiO_2$ with part of the oxygen replaced by fluorine and chlorine. The composition cannot be considered as definitely established as yet, and the very peculiar interest of the mineral makes it deserve further examination. The zunyite forms the gangue of an uncrystallized sulphide of lead and arsenic to which the name Guitermanite, after Mr. Franklin Guiterman, has been given. When fresh it is of a bluish-gray color, possesses a slight metallic luster, a hardness of about 3 and a specific gravity of 5·94. Analyses on two portions afforded:—

	S	As	Pb	Cu	Ag	Fe	Zunyite	
1.	⅔ 19·67	13·40	63·60	0·17	0·02	0·43	1·77	=99·06
2.	⅔ 19·56	13·00	61·63	0·17	0·02	0·88	3·82	O 0·55=99·63

Deducting a little lead sulphate, free sulphur and pyrite there remain S 17·68, As 13·00, Pb 59·85, Cu 0·17=90·70, which leads to the provisional formula $3As_2S_3$, 10PbS.

Another article by Dr. Hillebrand describes the occurrence and gives analyses of several interesting minerals from the American Eagle Mine, Tintic District, Utah, viz: *olivenite* in crystals, also in compact fibrous form; *conichalcite* in emerald-green globular forms with radiated structure; *chenevixite* in olive-green to greenish-yellow compact masses imbedded in the ore; also *jarosite* and a hydrous calcium arsenate in fine silky white needles. He also describes *bindheimite* from Secret Cañon, Nevada; *zinckenite* from the Brobdignag Mine, Red Mountain, San Juan County, Colorado; *melonite* from Boulder County, Colorado.

10. *On Colemanite, the new borate of lime.*—In the December number of this Journal, a preliminary notice was given by Professor A. Wendell Jackson of the crystalline form of the new borate of lime from Southern California, called Colemanite by Mr. J. T. Evans. Professor Jackson has now published an exhaustive monograph on the same subject in Bulletin No. 2 of the California Academy of Sciences, before which body his paper was read Oct. 6, 1884. His results show colemanite to be one of the most remarkable of minerals both in the beauty and perfection of the crystals, and the complexity of their forms. The crystals are generally clear and colorless with brilliant faces and vary for the most part from 5 or 6 mm. to 30 mm. in thickness. In some cases they line the cavities of large geodes in the massive mineral, forming most beautiful mineralogical specimens. Professor Jackson accepts the same axial ratio in his monograph as was given in the notice referred to, viz:

$$a : b : c = 0{\cdot}774843 : 1 : 0{\cdot}540998 : \beta = 69° 50' 45''.$$

He gives also a list of nearly forty planes which he has identified upon the crystals under examination. The crystals have a perfect cleavage parallel to the clinopinacoid and the habit varies from medium to short columnar, the unit prism ordinarily predominating; a striking feature is their resemblance in form to crystals of datolite. Professor Jackson's paper contains a long list of measured and calculated angles, the close agreement of which is an evidence of the perfection of the crystals. There are also four plates with a large number of figures, and a linear projection. It is not often that a new mineral species admits of so thorough a crystallographic examination. Prof. Jackson states that the locality from which the crystals examined came was Calico District, San Bernardino Co., California (not Death Valley, where, however, the mineral also occurs).

The chemical analyses by Mr. J. T. Evans have led to the formula $2CaO, 3B_2O_3+5H_2O$ or $Ca_2B_6O_{11}+5H_2O$; it is very near both priceite and pandermite (See Syst. Min., App. II, III), from the latter it differs in containing two molecules more water.

The same mineral has been studied by several other mineralogists, and their results confirm those of Professor Jackson, though made on a smaller selection of material; see vom Rath and Bodewig in the Verhandl. Nat. Verein d. preuss. Rheinl. u. Westf., pp. 333 to 342, and Hiortdahl, Zeitsch. für Kryst., x, 25. An analysis by Bodewig led to the same result as that given above; that of Hiortdahl varied somewhat, probably from want of purity in the material. Hiortdahl shows that the optic axes are in a plane normal to the clinopinacoid, the acute bisectrix lies in the obtuse axial angle and is inclined 26° 25′ (for Na) to the edge of the base and clinopinacoid; the interior angle of the optic axes $2Va=55°\ 21'$, and the index of refraction $\beta=1{\cdot}5876$.

11. *On Koninckite, a new hydrated phosphate of iron.*—M. Cesàro has recently described a new iron phosphate from Visé, Belgium, which he has named after Professor De Koninck of Liège. It occurs in small globular forms consisting of radiating needles, transparent and nearly colorless. Examined carefully these needles prove to have a single perfect cleavage and to belong to the monoclinic system. Its hardness is 3·5, and specific gravity 2·3. It fuses easily to a black bead. An analysis yielded the following results:

	P_2O_5	Fe_2O_3	Al_2O_3	H_2O
(?)	34·8	33·9	[4·5]	26·8=100

For this the formula $Fe_2O_3, P_2O_5+6H_2O$ is calculated. Koninckite occurs associated with richellite, a hydrous fluo-phosphate of iron recently described by the same author (see this Journal, xxvi, 411).—*Mem. Soc. Geol. Belgique*, xi, 247.

12. *Analysis of Titanic Iron Sand from Brazil;* by J. B. Mackintosh. (Communicated).—The mineral analyzed was given by Mr. John Gordon, Jr., of Rio Janeiro to Professor Egleston, at whose suggestion the present examination was made. It occurs

in river or beach sands, in small rounded grains, associated with monazite, garnet, tourmaline, quartz and mica. It does not dissolve sufficiently in hydrochloric acid to give the titanium reaction with tin. Its specific gravity is 4·2. An analysis afforded:

TiO_2	59·20
Fe_2O_3	32·11
FeO	4·9
MgO	1·73
SiO_2	1·16
	99·09

Omitting the silica which is present as a mechanical admixture, these figures lead to the provisional formula $3(Fe_2O_3, 3TiO_2) + 2(FeO, TiO_2)$. The oxygen ratio between protoxides, sesquioxides and titanic acid = 1 : 4·5 : 11, or for all the bases to titanic acid = 1 : 2. About 85 per cent then of the mineral is composed of the normal titanate of *sesquioxide* of iron, the other 15 per cent being normal titanate of the protoxide, which separates it widely from ordinary menaccanite.

13. *Mineralogical Notes;* by Edo Claassen.—Mr. Claassen states that he has found ·08 per cent vanadic oxide and a trace of chromium oxide in the magnetite of Newboro, Canada; also ·028 per cent vanadic oxide, ·006 per cent chromium oxide and 5·27 per cent titanic oxide in the magnetite sand found on the shore of Lake Erie.

14. *Minerals from Middletown, Conn.*—In the note No. 9 on page 263, the closing lines of the first paragraph, relating to cerussite and pyromorphite, should be erased.

III. Botany and Zoology.

1. *Origin of the Fauna and Flora of New Zealand.*—Captain F. W. Hutton, of New Zealand, in articles published in the Annals and Magazine of Natural History, xiii, 425 (1884), and xv, 78 (1885), presents his views on the origin of the New Zealand fauna and flora. The earlier paper reaches the conclusion that, in the Lower Cretaceous, New Zealand formed part of a large South-Pacific continent extending from New Guinea to Chili, and so received species of plants and animals from Australia, Polynesia and South America; and also that in the Eocene another invasion of species from the same sources took place; but New Zealand in each remained an island, much larger than at present. In the later paper he considers the facts with reference to invasions of Antarctic and North-temperate species during the Pliocene. The following facts and views are from this paper.

New Zealand has, to the *eastward*, Chatham Isles (one volcanic peak of which is 600 feet high) 400 miles off, and the Antipodes Islands (700 feet in greatest height) 450 miles off; to the *southward*, the Aucklands (2000 feet high) 240 miles off, Campbell Island (1600 feet high) 420 miles off, and Macquarie Island, 600 miles distant from New Zealand.

As large a number of New Zealand living crustaceans exist in South America as in Australia, half as many antarctic flowering plants, the grasses excluded, and one-third as many of the grasses. Five of the New Zealand fresh-water fishes exist also in Australia and two in South America. Hence the conclusion that a former land-connection existed between these countries, as had been suggested by Sir J. Hooker, Mr. H. N. Moseley, and Mr. Wallace.

Tasmania and New Zealand, 600 to 900 miles apart, have 103 species of flowering plants (6·75 per cent) in common, but only two fresh-water fishes, and no fresh-water or land shells with one doubtful exception.

The elevation in the antarctic regions supposed to be thus indicated is referred to the Pliocene. With regard to the extent of New Zealand at the time the author observes that all the outlying islands are included within this land area by M. Blanchard; only Chatham Island, by M. A. Milne-Edwards; and probably all the area eastward to Chatham and south to Macquarie, by Wallace. At Chatham Islands the New Zealand species include 4 out of 21 land birds, and one of them, the gold cuckoo, is migratory to New Zealand and Australia; (on Pitt's Island) one lizard (*Mocoa Zelandica*), a slug (*Janella bitentaculata*), a land shell (*Thalassia Neozelanica*). There is one flightless rail (*Cabalus modestus*) on Pitt's Island, allied to *Ocydromus*, but nothing of *Apteryx*, *Stringops* or *Ocydromus*.

At the Aucklands are found a number of New Zealand land birds, three species of land shells and the slug *Janella bitentaculata*. Of the flowering plants of Auckland, Campbell and Macquarie Islands about 75 per cent occur on New Zealand. A connection of all these southern islands with New Zealand is hence probable. And as these islands contain antarctic species not occurring in New Zealand it is reasonable to conclude that the species reached New Zealand from the southward. Wallace makes the route for the Fuegian plants to have been through the South Shetlands from the Antarctic continent; and Sir J. Hooker makes Fuegia to be related more or less evidently in its plants with all the Antarctic islands, excepting those in the vicinity of New Zealand.

At the Kermadec Islands, 450 miles north of New Zealand, 14 per cent of the plants are endemic species; and the isolation of the group may therefore date from the same time.

Chatham Isles, the Aucklands and Campbell Island are related in their rocks to New Zealand, which are mainly non-volcanic. All the other antarctic islands are volcanic excepting South Georgia which has a mountain range of slate.

The author regards it as probable that an antarctic continent south of Africa, including Tristan d'Acunha and Kerguelen Island, existed from the Eocene to the Pliocene, but that a partial submergence separating off New Zealand occurred between the Eocene and Pliocene; and that Graham's Land, Enderby's Land and Victoria Land are some of the remnants of this land.

The succession of geographical changes was then as follows. Before the close of the Jurassic—as Jurassic and Triassic rocks, fossils, and coal beds show—New Zealand was the southern portion of a continental land extending through Australia to India, the Indo-oceanic continent of Mr. H. F. Blanford. After that a separation from Australia took place, and in the Upper Cretaceous New Zealand was smaller than now. But in the Eocene it spread out again, as above remarked, and plants and animals were received from the north and south; and again in the Pliocene, when immigration from the south took place. Then followed a sinking below the present level, to be elevated to its present level again during the Quaternary.

"But the more the geology and palæontology of large geographical regions, like North America or Europe, are studied, the more clearly we see that subterranean movements have affected large regions simultaneously, or nearly simultaneously, and that the local deviations from uniformity are comparatively small. So it comes about that we have in each large geographical area a series of rock systems which are nearly synchronous over the whole area, although not synchronous with those in other and distant areas. I think that our knowledge of the palæontology of Australasia is already sufficient to show that we have here also another of those large geographical areas which, when viewed on a large scale, has been moved uniformly; and therefore that the rock-systems of New Zealand can be correlated with those of Australia, and perhaps, in the earlier periods, with those of the peninsula of India."

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"Our fauna and flora is indeed a standing protest against the views of those naturalists who would make the winds scatter abroad insects and seeds of plants over hundreds of miles, and who imagine land-shells and lizards to float about on logs for days and weeks together without being killed."

With regard to the *Glacial era of the South Pacific*, Captain Hutton observes that it was not an era of unusual cold; that no glaciers ever reached the sea-level, although extending far beyond their existing limits; that there are no true erratics; that the land probably stood higher than now by perhaps 3,000 or 4,000 feet, and thence came the greater extension of the ice.

This era of the greater elevation of the land and of the large extension of the glaciers was, according to Captain Hutton (and "almost all New Zealand geologists"), earlier than that of the northern Glacial period, and probably coincident with the Pliocene elevation. One argument supporting this conclusion is the number of existing endemic species on the island. Again, marine beds, supposed to be Miocene—the "Pareora system"—containing 20 to 45 per cent of living species, are found along New Zealand from Southland to Auckland. They indicate a warmer climate than the present. Another later series is the "Wanganui system" containing 70 to 90 per cent of living spe-

cies, and probably of newer Pliocene age. The era of elevation is placed between these two of depression. A later series, containing living species, and therefore Quaternary, occurs at many places on both islands.

The question as to glacial phenomena in Australia has been decided adversely by Mr. Tenison Woods and Mr. Howitt; but probable glacial striæ on Victoria are described by Mr. G. S. Griffiths, and farther north by Professor R. Tate. Marine Pliocene beds have been reported as occurring in Victoria up to 1720 feet above the sea.

IV. Miscellaneous Scientific Intelligence.

1. *Part II, Vol. VII of the Transactions of the Seismological Society of Japan.*—This volume, recently received, is mostly occupied by a paper from Professor John Milne, on three hundred and eighty-seven earthquakes observed during two years (Oct., 1881, to Sept., 1883) in North Japan. Besides a statement of the instruments used and the stations occupied, and a catalogue of the earthquakes, this gives one hundred and twenty-three maps of the areas affected by single earthquakes, one general map shaded to represent the distribution of volcanic and seismic activity in Japan, and sixty-six figures of the tracings made by the various recording instruments. Many of these latter are extremely curious and interesting, but must be *seen* to be appreciated. No description can do them justice. The earthquakes are tabulated with respect to their distribution in space and time and their relation to other natural phenomena. A few results reached may be briefly mentioned. He finds that eighty-four per cent of the earthquakes originated under the ocean or on the sea board; that the winter intensity is nearly three and a half times as great as the summer intensity; that there is a general coincidence between the maximum of earthquakes and the minimum of temperature and that there were 11·2 per cent more earthquakes at low water than at high water. Sixteen earthquakes occurred simultaneously in separated areas, not being felt in the intervening localities. He also finds that the indications of exactly similar instruments may vary considerably at stations only a few hundred feet apart, and hence concludes that the amplitude and period of the vibration constituting an earthquake is very largely dependent upon the character of the soil and other local circumstances. C. G. R.

2. *Proceedings of the Colorado Scientific Society*, vol. i, 147 pp., with a map. 1883–84.—The Colorado Scientific Society, the first meeting of which was held in January, 1883, has now published volume I of its Proceedings: it contains a number of valuable articles, one of which is noticed at length in another place. The volume closes with a list of the important minerals of Colorado. It is announced that the Society expects to issue one volume annually in future. The officers for 1885 are Presi-

dent Dr. W. F. Hillebrand, Vice-President Mr. P. H. van Diest, Secretary and Treasurer Mr. F. F. Chisolm.

3. *Report on the Waters of the Hudson River together with analysis of the same, made to the Water Commissioners of the City of Albany;* by C. F. CHANDLER, Ph.D., Jan., 1885.—In this paper the amount of soluble matters in different river waters is given as follows: in grains per gallon of 231 cubic inches and in parts per 10,000.

	Per gallon.	Per 10,000 parts.	Mineral matter.
Hudson River at Albany	4·665–7·581	8·00–13·00	4·50–9·80
Mohawk River	6·250	10·70	9·00

Of the amount, 1·50 to 5·00 in 10,000 are organic and volatile matters, deducting which leaves for the mineral matters in the Hudson River waters 4·50 to 9·80 inch in 10,000 parts as above stated, and for the mean amount 7·11. The average volume of the Hudson at Albany is given at 618,111 cubic feet per minute, equal to an average daily flow of 6,677,000,000 gallons. The investigation for this report had special reference to the purity of the waters for city supply.

4. *The life of James Clerk Maxwell, with selections from his correspondence and occasional writings;* by L. CAMPBELL, M.A., LL.D., Professor of Greek in the University of St. Andrews, and Wm. Garnett, M.A. New edition, abridged and revised, 422 pp. 12mo. London, 1884. (Macmillan & Co.).—This admirable biography of one of the greatest of physicists and mathematicians and best of men is an abridgment of the larger work published two years since.

OBITUARY.

JOHN GWYN JEFFREYS, the distinguished veteran conchologist, died suddenly on January 24th, at his residence in London. Mr. Jeffreys was born January 18, 1809, at Swansea, Wales. His earlier papers on conchology date back to 1828, and during the past fifty-six years he has been a constant contributor to the literature of his favorite branch of science. His most extensive work is the "British Conchology," in five volumes. He took a leading part in the earlier private dredging expeditions around the British coast, many of which were carried out in his yacht, the "Osprey," in 1861 to 1868. When the deep-sea dredgings were undertaken, with the aid of the English government, in 1868 to 1870, in the "Lightning" and "Porcupine," off the coasts of Great Britain and in the Mediterranean, he took an active part in those explorations. He also went in the "Valorous" to Baffin's Bay, in 1876, for the chance of doing some arctic deep-sea dredging. In 1871 he visited the United States and Canada for a short time, and while here made a brief visit to the U. S. Fish Commission, then in its first year of existence, and took part in a few short dredging trips in Vineyard Sound. In 1880 he went by invitation on the French dredging expedition of "Le Travailleur," in the Bay of Biscay. For several years past he has been engaged in publishing the conchological results of these various

expeditions, and at the time of his death he was still actively engaged upon the shells of the Lightning and Porcupine expeditions. The greater part of these have already been published by him in the Proceedings of the Zoological Society, and probably the work on most of the remaining groups of Gastropoda was well advanced, if not completed, before his death.

To Mr. Jeffreys more than to any other conchologist science is indebted for the careful comparison of the European shells, both recent and fossil, of the numerous British and continental collections, and the consequent elimination of numerous nominal species and the disentanglement of their confused synonymy. He was especially interested in the geographical and geological distribution of European mollusca, and contributed very largely to a more correct and extended knowledge of these subjects.

Mr. Jeffreys had accumulated during a long and active life a very valuable and extensive collection of European shells, including a great number of types of his own species, as well as those of other writers. His entire collection was purchased by the U. S. National Museum two years ago, and a considerable part of it has already been received there. It should be a matter of congratulation to American naturalists that this unique collection will be preserved in this country and cared for in a manner commensurate with its scientific value. A. E. V.

Searles Valentine Wood, Jr., author of numerous valuable papers on British Geology—largely the Tertiary and Quaternary—died on the 14th of December last, in his fifty-fifth year. He was the son of the well-known paleontologist of the same name.

Elementary Text-book of Zoology, General Part and Special Part, Protozoa to Insecta. By Dr. C. Claus, Prof. Zool. and Comp. Anat. Univ. Vienna, Director Zool. Station at Trieste; translated and edited by Adam Sedgwick, M.A. Fellow and lecturer of Trinity College, Cambridge, with the assistance of F. G. Heathcote, B.A., Trinity College, Cambridge. 616 pp. 8vo, with 491 woodcuts. Part 2, Mollusca to Man, with 706 woodcuts. New York: 1885. (Macmillan & Co.)

Scientific papers and addresses by George Rolleston, M.D., F.R.S., Prof. Anat. and Physiology Oxford; arranged and edited by Wm. Turner, LL.D., F.R.S., Prof. Anat. Univ. Edinburgh, with a biographical sketch by Edward B. Tyler, D.C.L., F.R.S., Keeper of the Museum, Oxford. In two vols., 948 pp. 8vo, with portrait, plates and woodcuts. Oxford (Clarendon Press). New York (Macmillan & Co.)

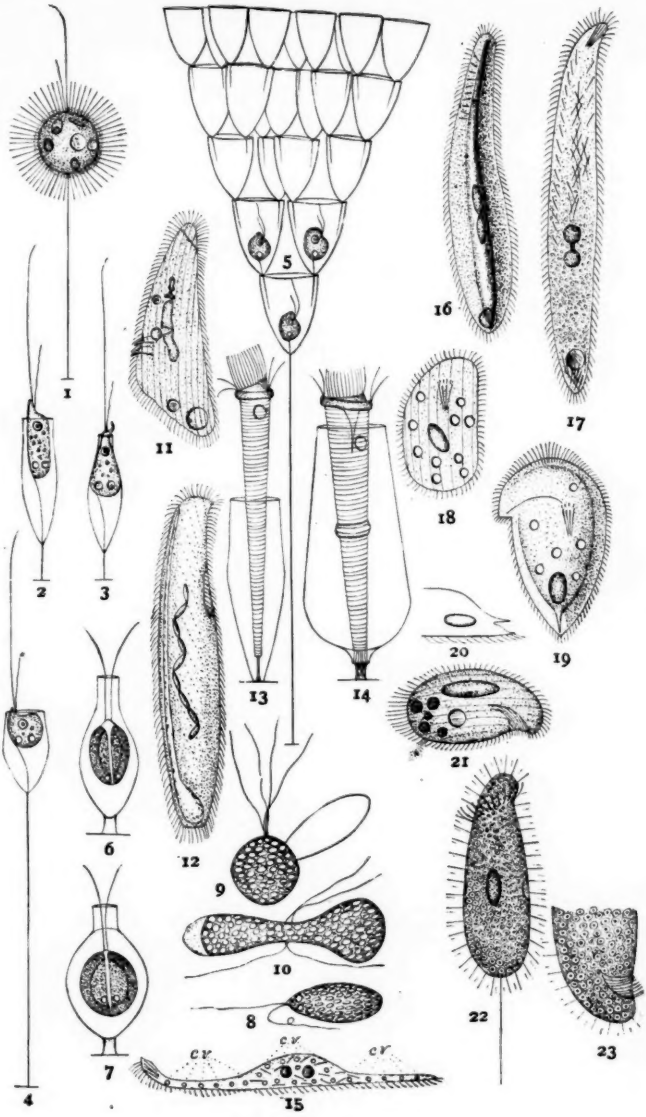
Om Lydorganer hos Fiske. En physiologisk og comparativ-anatomisk Undersogelse, ved Wm. Sorensen, 246 pp. 8vo, with 4 plates. Copenhagen, 1884. (V. Thaning & Apels.)

Memoir upon the Formation of a Deaf Variety of the Human Race, by Alexander Graham Bell. Paper presented to the National Acad. Sci., Nov. 13, 1883, 86 pp. 4to.

Gleanings from outcrops of Silurian Strata in the Red River Valley, by J. Noyes Panton, M.A., paper read before the Manitoba Historical and Scientific Society, Winnipeg, Nov. 27, 1884.

Catalogue of Fossil Mammalia in the British Museum. Part I, containing the Orders Primates, Chiroptera, Insectivora, Carnivora and Rodentia; by Richard Lydekker, B.A., F.G.S., etc. London. 1885.—The British Museum "Catalogues" are largely descriptive, and on this account as well as the extent of the collections have great value.

The Prehistoric World or Vanished Races; by E. A. Allen, 820 pp. 8vo, with plates and cuts. Cincinnati, 1885. (Central Publishing House.)



FRESH-WATER INFUSORIA.